

**LEVEL III**

**12**  
B.S.

# RELIABILITY, AVAILABILITY AND MAINTAINABILITY DESIGN PRACTICES GUIDE

VOLUME 2



Prepared for  
HEADQUARTERS, U.S. ARMY MATERIEL DEVELOPMENT  
AND READINESS COMMAND, DRCQA-E  
5001 EISENHOWER AVENUE  
ALEXANDRIA, VIRGINIA 22333  
under Contract DAAK80-80-C-0781

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This guide compiles, in one source, selected real-world practices (techniques or tools) available to the Army engineer and manager to improve the reliability, availability, and maintainability (RAM) characteristics of equipment. It is the purpose of this guide to provide a medium for the exchange of experience and knowledge of DARCOM engineers, to minimize re-inventing the wheel, and to provide a single compendium of techniques currently in use and available for adaptation to other systems and equipment. These techniques vary greatly in application, source, and theory.		

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## 5.1 DATA ANALYSIS



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** August 1979

**Title:** Geometry of the Total Time on Test Transform

**Synopsis:**

Total time on test (TTT) plots provide a useful graphical method for tentative identification of failure distribution models. Identification is based on properties of the TTT transform. New properties of the TTT transform distribution are obtained. In particular, it is shown that a non-IFRA distribution may have an anti-starshaped transform. Hence, TTT transforms may only be useful for determining local properties of the failure rate function and not the failure rate average function.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. R. E. Barlow	<input type="radio"/> Conception
<b>Address:</b>	California University Operations Research Center Berkley, CA	<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Post-Production
<b>Commercial</b>	(415) 642-6000	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** August 1979

**Title:** Graphical Computerized Analysis of Data Tolerance Points

**Synopsis:**

This program utilizes the abilities of a FORTRAN program called "NANCY" to plot lower and upper limit tolerances by means of a histogram. The output provides information such as range, mean, variance, median, standard deviation, percentage of tolerance, and 95 percent confidence-range prediction.

This program affords the user improved visibility of his test data, thus speeding and improving his evaluation of the data.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
Weapons	XM231, BRL 556 MM	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. H. Lazar		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment
Address: ARRADCOM Dover, NJ 07801		
Telephone:		
Autovon 838-5734 Commercial (201) 328-5374		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** August 1979

**Title:** Underwater Acoustic Materials Data Analysis

**Synopsis:**

A computerized data acquisition and analysis system has been developed to completely automate the evaluation of underwater acoustic materials used with a waveguide. A software sampling technique is used whereby the complete time-varying analog representation of an acoustic signal is converted into digital format and then processed. This system provides real-time data analysis with hard-copy and graphical output.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. M. H. Main	<input type="radio"/> Conception
<b>Address:</b>	David Taylor Naval Ship Research and Development Center	<input type="radio"/> Validation
<b>Telephone:</b>	Annapolis, MD	<input type="radio"/> Full Scale Development
<b>Autovon</b>	281-2111	<input type="radio"/> Production/Improvement
<b>Commercial</b>	(301) 267-2111	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** September 1980

**Title:** A Bayesian Methodology for Accelerated Life Testing

**Synopsis:**

In this procedure, a Bayesian approach is adopted for estimating the failure rate at the use condition. No parametric assumptions are made about the failure distributions or the acceleration functions. The failure rate estimate is used to obtain the reliability at use condition.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Nozer D. Singpurwalla Frank Proschan  <b>Address:</b> George Washington University Florida State University  <b>Telephone:</b> Autovon Commercial (202) 676-7515		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** September 1980

**Title:** Nonparametric Analysis of Life Test Data

**Synopsis:**

A procedure has been developed for obtaining inferences from accelerated life tests without assuming a parametric family of failure distributions at the different stress levels. The time transformation law is a generalization of the familiar "inverse power law." The statistical estimate of the failure distribution of use-conditions stress is shown to be statistically consistent.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Nozer D. Singpurwalla J. Sethuraman <b>Address:</b> George Washington University Florida State University <b>Telephone:</b> Autovon Commercial (202) 676-7515		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** September 1980

**Title:** Fatigue Failure Prediction

**Synopsis:**

Strain gage data are acquired from a component that is being tested in the laboratory or in an operational system. The data are in the form of a time history and represent the loadings the component would experience under actual use.

These data are read into the computer, and a Rain-Flow Cycle counting algorithm is applied to the digitally sampled strain history. The characteristics of the metal under test are also stored in the computer. The strain energy at each frequency is summed using Miner's rule. The output is compared to the S-N curve of the materiel, and a prediction of how long the materiel will last under the test loadings is made.

The program is written in FORTRAN.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Trucks, Tanks	Frame, Torsion Bars	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Dr. Richard A. Lee Address: TACOM Warren, MI 48090 Telephone: Autovon 273-2228 Commercial (313) 573-2228		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis, ANALYSIS/Data/  
Reliability, CONTRACT APPLICATIONS/Reliability

**Date:** November 1980

**Title:** Efficient Methods for Assessing Reliability

## Synopsis:

The AMSAA reliability growth model makes efficient use of reliability information collected during a test phase in which the system configuration is changing. By applying this model to development test data, it is often possible to demonstrate reliability requirements without the need for a follow-on fixed configuration test phase.

AMSAA has developed a statistical methodology, which enables project management to evaluate the need for such follow-on testing. When the follow-on test phase is conducted, this methodology provides increased efficiency by the use of an extended model, which allows a unified treatment of the data from two separate test phases. The amount of testing can therefore be reduced and, at the same time, both Government and contractor risks are held to reasonable levels.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Grady Miller  <b>Address:</b> Director, US Army Materiel Systems Analysis Activity Attn: DRXSY-RM  <b>Telephone:</b> Aberdeen Proving Grounds, MD 21005 <b>Autovon</b> 283-5882 <b>Commercial</b> (301) 278-5882		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** July 1980

**Title:** Tables for Comparing Two Mean Time Between Failures (MTBF)  
for Unequal Test Times; AMSAA-TR-226; AD-A070371

**Synopsis:**

This technical report presents tables for comparing two MTBF for unequal test times. Utilization of these tables facilitates the carrying out of the exact method for this statistical test. Tables are tabulated for 0.001, 0.01, 0.05, 0.10, and 0.20 levels of significance, with the ratio of the two test times ranging from 0.1 to 5.0 by increments of 0.1, and the total failures ranging from 1 to 100.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> R. E. Mioduski Director, US Army Materiel <b>Address:</b> Systems Analysis Activity Attn: DRXSY-RE Aberdeen Proving Grounds, MD 21005 <b>Telephone:</b> Autovon 283-2135 Commercial (301) 278-2135		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** November 1980

**Title:** Introduction to the Application of Statistical Concepts to Test and Evaluation

**Synopsis:**

The material is designed to familiarize the reader with the various statistical concepts and techniques required to thoroughly understand the relationship between test design, assessment, and projection of population characteristics. Basic RAM models are defined, estimates and confidence intervals for parameters are discussed, and hypothesis testing is presented.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> John C. Conlon  <b>Address:</b> Director, US Army Materiel Systems Analysis Activity, ATTN: DRXS-Y-RM Aberdeen Proving Ground, MD 21005  <b>Telephone:</b> Autovon 283-5882 Commercial (301) 278-5882		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis

**Date:** November 1980

**Title:** A Program for Computing Truncated Sequential Design Plans

**Synopsis:**

The program is designed to compute a test design plan for single-shot systems. Input to the program is a fixed truncation point (if not specified, one will be computed), upper bounds on consumer and producer risk for a minimum acceptable value and a specified value, and an optimization requirement (average, maximum, and minimum expected sample sizes over a user-specified range). The output of the program includes the test plan, the actual consumer and producer risks, the expected sample sizes (average, maximum, and minimum), and a graph of the power curve for the test.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> John C. Conlon  <b>Address:</b> Director, US Army Materiel Systems Analysis Activity, ATTN: DRXS-Y-RM, Aberdeen Proving Ground, MD 21005  <b>Telephone:</b> Autovon 283-5882 Commercial (301) 273-5882		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis, ANALYSIS/Data

**Date:** December 1980

**Title:** A Computer Program for Estimation of Parameters of the Weibull Intensity Function and for the Cramer-Von Mises Goodness of Fit Test; AMSAA TR-279-REV; AD-A085112

**Synopsis:**

This report describes the structure and use of a digital computer program written in standard FORTRAN, which can be used to obtain the maximum likelihood estimates of the parameters of the Weibull intensity function. The program also performs the Cramer-Von Mises goodness of fit test. (Author)

The program listing is provided in the referenced report. The furnished program was written for the CDC Cyber 76 Computer; transfer to other computers should be straightforward.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. H. Betz  <b>Address:</b> Director, US Army Material Systems Analysis Activity; ATTN: DRXSY-RE Aberdeen Proving Ground, MD 21005  <b>Telephone:</b> Autovon 283-2135 Commercial (301) 278-2135		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Analysis/Reliability

**Date:** November 1980

**Title:** Statistical Analysis of Sonobuoy Reliability for the ALS-II  
and P-3 Modes of Deployment; NADC-78156-20; AD-B031234

**Synopsis:**

NADC has developed three types of tests of hypotheses for use in comparing the demonstrated reliability of sonobuoys of various types and methods of deployment. These tests were utilized to compare seven types of sonobuoys deployed in both the ALS-II and P-3 modes of deployment.

The three tests of hypotheses are:

1. Uniformly most powerful ( $\alpha$ -level) test in original and normal approximation forms
2. Neyman-Pearson conditional maximum likelihood ratio test in asymptotic form
3. Modified chi-square test

For tests 2 and 3, simple expressions for the power functions were developed.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Sonobuoy	Various	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Dr. I. R. Goodman		<input type="radio"/> Conception
Address: Naval Air Development Center ATTN: Systems Department (Code 2031) Warminster, PA 18974		<input type="radio"/> Validation
Telephone: Autovon 441-3168 Commercial (215) 441-3168		<input type="radio"/> Full Scale Development
		<input checked="" type="radio"/> Production and Deployment

**52 DATA COLLECTION**



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Collection

**Date:** August 1979

**Title:** RAM/LOG Data Collection Program

## Synopsis:

If RAM logistics and operating and support costs are to be used as discriminators in selecting a weapon system, action must be taken to obtain timely, accurate, and applicable data. The RAM/LOG data collection system is designed to satisfy this requirement. This method is based on years of experience with existing data systems.

The RAM/LOG data collection system is based on the following concepts:

1. Integrated Data Base. The data base has to be composed of data from many different sources. The RAM/LOG system is designed to be compatible with the contractor data items generated during an engineering development program in addition to controlled data collected during tests.

2. Data Elements and Flow Processes. One of the many requirements of RAM/LOG is its emphasis on the quality of the data. The data are well controlled and receive numerous quality audits on-site, as well as in the (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Helicopters	UH-1, UTTAS, 214, AAH, AH-1 series aircraft	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Roger Hoffman U.S. Army Troop Support and Aviation Readiness Command <b>Address:</b> Attn: DRSTS-QSM(2) 4300 Goodfellow Boulevard St. Louis, MO 63120 <b>Telephone:</b> <b>Autovon</b> 698-2158 <b>Commercial</b> (314) 268-2153		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: RAM/LOG Data Collection Program

Synopsis: (Continued)

central facility. The controlled data collection is an in-depth and detailed event-recording process that is evaluated on an event basis for determining contractor performance.

3. Utilization of Feedback and Output Designs. The data system takes into consideration the fact that it will have to be used with various models and by those involved in various technical disciplines with different objectives. The data system is structured to provide practically any information required to exercise most RAM logistics and cost analysis models.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Collection

**Date:** August 1979

**Title:** Common Test Data Collection System (CTDCS)

**Synopsis:**

Using the RAM/LOG system developed for helicopters, DARCOM has developed a system that provides the needed flexibility to collect data on all types of systems while insuring that all needed data are collected. CTDCS is an event-oriented data system that permits the test community to select the data elements required for a particular test, enter data into a computer (and perform automatic editing of the data), and have access to the data via the System 2000 Data Base Management System. Commonality of the data system will permit more flexible sharing of the data between tester, evaluator, project manager, and development and readiness commands. In addition to direct access, standard reports, including RAM Summary, EPR, and LSAR, will be produced by the system.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
Missile	GSRS	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. D. Leach		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment
Address: HQ-DARCOM, DRCQA-E 5001 Eisenhower Avenue Alexandria, VA 22333		
Telephone: 284-8916		
Autovon 284-8916 Commercial (202) 274-8916		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Collection

**Date:** August 1979

**Title:** Procedures for Collecting RAM Test Data

**Synopsis:**

A study has been completed on the methods to acquire and store data on the Reliability, Availability, and Maintainability (RAM) of electrical and mechanical systems. Data acquisition methods previously used by the Army Corps of Engineers were reviewed, and new methods and equipment now being developed were evaluated. In a report on the study, forms are proposed to aid in the collection and handling of information in a logical manner. Methods for storing data either manually or by computer are also presented. The results of the study show that new computer systems, together with available communications equipment and the proposed forms, can be combined to provide an efficient and economical means of acquiring and storing RAM data.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. E. M. Takemori	<input type="radio"/> Conception
<b>Address:</b>	Construction Engineering Research Lab	<input type="radio"/> Validation
<b>Telephone:</b>	Champaign, IL	<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Deployment
<b>Commercial</b>	(217) 352-6511	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Data Collection/Data Analysis,  
ANALYSIS/Data

**Date:** November 1980

**Title:** TESTDATA Data Base

## Synopsis:

The Technology and Programs Division of the Product Assurance and Test Directorate, CORADCOM, has developed a data base system to store and retrieve essential elements of information for testing conducted on CORADCOM equipments. The system provides an audit trail of test incidents and is responsible to the reporting requirements of the Directorate. System 2000 is the data base management system used for TESTDATA. A definition tree was developed, data input and retrieval procedures were established and utilized, and data update procedures have been performed. Analysis programs have been written and exercised for specific systems. The system is responsible to specific requirements of various programs.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<ul style="list-style-type: none"><li>● Reliability</li><li>● Availability</li><li>● Maintainability</li></ul>
Point of Contact		Life Cycle Phase
<p><b>Name:</b> Ms. Grace A. Marseglia</p> <p><b>Address:</b> CORADCOM, DRDCO-PT-P Fort Monmouth, NJ 07703</p> <p><b>Telephone:</b> Autovon 995-2205 Commercial (201) 544-2205</p>		<ul style="list-style-type: none"><li>● Conception</li><li>● Validation</li><li>● Full Scale Development</li><li>● Production and Deployment</li></ul>

### 6.3 RELIABILITY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** TAFF for ROLAND

## Synopsis:

The Test, Analyze, Find, and Fix (TAFF) technique is used throughout the ROLAND program from board test on up to system operational test. At each level, the basic procedure is to test the device, analyze any failures which occur, and offer corrective actions.

This technique identifies recurrent failure modes before they occur in the field, increasing the resulting reliability. In addition, generally increased confidence in the equipment results from the intensive analysis of the equipment.

TAFF has been widely used by the Air Force, Navy, and industry in the development of various weapon systems, especially in complex electronic equipment.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Missile	ROLAND	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. D. Crocker		<input type="radio"/> Conception
<b>Address:</b> MICOM-DRDMI-QRW Redstone Arsenal, AL 35809		<input type="radio"/> Validation
<b>Telephone:</b>		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> 746-5115		<input checked="" type="radio"/> Production and Deployment
<b>Commercial</b> (205) 876-5115		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** Experimental Designs for Testing of Army Materiel

**Synopsis:**

The statistical theory of the design of experiments provides an effective method of test planning and data analysis. This theory provides a means of quantifying sampling risks and a method for the most efficient structuring of test programs so that test efforts can be minimized while valid estimates of the test results can still be obtained.

Incomplete block designs have proved to be particularly effective in evaluating the serviceability of large numbers of lots in storage in the ammunition stockpile. Factorial and fractional factorial designs have been proven effective in the conduct of early development tests from which large numbers of factors that may affect the performance of a new system must be evaluated.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Ammunition Systems		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. W. Eissner		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address: AMSAA-DRXSY-R Aberdeen Proving Grounds, MD 21005		
Telephone:		
Autovon 283-4064		
Commercial (301) 278-4064		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** Demonstration Test Model for Automated Production Line

**Synopsis:**

A statistical approach has been developed for planning and conducting a demonstration test of the production capability of automated production lines. The proposed test is based on the concept of capability ratio, defined as the ratio of the product of system availability and actual production rate to required production output. A statistical test of hypothesis was formulated, wherein use is made of data measuring true system performance characteristics such as time-to-failure and time-to-repair distribution and production rates. In addition, a method of selecting test duration times was provided, with tables and formulas for determining test times based on the desire to demonstrate a given capability ratio with specific levels of significance and confidence.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Production Line		<input type="radio"/> Reliability <input checked="" type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. Mardo		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
<b>Address:</b> ARRADCOM - Product Assurance Dover, NJ 07801		
<b>Telephone:</b> Autovon 880-4758 Commercial (201) 328-4758		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** Accelerated Mission Test (AMT) - A Vital Reliability Tool

## Synopsis:

Accelerated Mission Test (AMT) is a method in which potential problems can be identified and anticipated before a system is operationally deployed. It provides the lead time necessary for early corrective measures to be taken, thereby improving a system's life-cycle cost and decreasing downtime.

Plans have been developed by the Air Force to conduct AMT on aircraft engines that have completed the overhaul or depot cycle. The purpose of the testing will be to identify potential problems associated with engine parts that have been repaired in accordance with overhaul procedures.

In the Air Force "Lead the Force" (LTF) Paper Century program, AMT revealed the onset of thermal cyclic distress in the hot section of F100 engines in only 350 hours of actual testing. This is an equivalent of four years of operational life, or approximately 1,300 hours. The AMT results provided time for hot section engineering changes to be implemented in the early production phase of the program.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Powerplants	F100	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> B. J. McDonnell		<input checked="" type="radio"/> Conception
<b>Address:</b> United Technologies Corporation Gov. Products Division P. O. Box 2691 West Palm Beach, FL 33402		<input checked="" type="radio"/> Validation
<b>Telephone:</b> Autovon Commercial (305) 582-6080		<input checked="" type="radio"/> Full Scale Development
		<input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** A Study of Truncated Sequential Probability Ratio Tests for Reliability Testing and Some New Results

**Synopsis:**

A new analytical procedure has been developed which can be used to analyze and evaluate sequential probability ratio test plans used for reliability demonstration. The methodology developed is capable of evaluating such test plans when the two lines which define the accept, reject regions are either parallel or nonparallel, with or without truncation considerations.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. A. L. Goel	<input type="radio"/> Conception
<b>Address:</b>	Dept. of Industrial Engineering and Operations Research	<input type="radio"/> Validation
<b>Telephone:</b>	Syracuse University	<input type="radio"/> P.R. Scale Development
<b>Autovon</b>	Syracuse, NY	<input type="radio"/> Production and Deployment
<b>Commercial</b>	(315) 423-4341	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** Navy Manufacturing Screening Program

**Synopsis:**

Continuing advances in electronics state of the art, plus increasing emphasis on reliability and early development testing, have increased the potential for providing a basically sound and inherently reliable design. As this potential has increased, so has the complexity and density of contemporary equipment packaging. This complexity amplifies the ever-present problems of detecting and correcting latent manufacturing defects.

The ability to detect simple anomalies through even the most intense visual inspection and bench checkout has become a thing of the past because of the complexity of current equipment. Effective manufacturing screens for the purpose of stimulating latent defects, whether or not such screens resemble expected mission environments, have become an absolute necessity. The Naval Material Command is striving to replace current and ineffective temperature cycling and low-level sinusoidal vibration with more stringent temperature cycling and random vibration in manufacturing screens such as burn-in and acceptance testing. (Continued)

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. W. J. Willoughby, Jr.	<input type="radio"/> Conception
<b>Address:</b>	Deputy Chief of Naval Material Department of the Navy Washington, DC	<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>	222-9058	<input type="radio"/> Production and Deployment
<b>Commercial</b>	(202) 692-9058	

**Title:** Navy Manufacturing Screening Program

**Synopsis:** (Continued)

An effective manufacturing screening program consisting of temperature cycling and random vibration has been adopted by the Navy, primarily for Navy contractors. Together, temperature cycling and random vibration provide a most effective means of decreasing corporate costs and increasing fleet readiness.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability

**Date:** August 1979

**Title:** Resource Requirements for Flight Test Reliability and Maintainability Programs; AD-B28900

**Synopsis:**

Flight test reliability and maintainability programs for new aircraft weapon systems are among several reliability and maintainability program areas receiving increased emphasis within the Air Force and Department of Defense. Specific requirements for results from flight test reliability and maintainability programs have recently been established by the Air Force. This study identified the resources needed to conduct a flight test reliability and maintainability program in which impacts of specific resource shortfalls are also identified to aid managers in making trade-offs of resource allocations to competing acquisition program areas.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. M. Dunigan		<input type="radio"/> Conception
<b>Address:</b> Air Command & Staff College Maxwell AFB, AL		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 875-1110		<input type="radio"/> Production and Support
<b>Commercial</b> (205) 293-1110		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Reliability/Data Analysis

**Date:** November 1980

**Title:** Reliability Index Determination (RID) Testing

**Synopsis:**

A reliability index determination (RID) test is a test whose purpose is to establish a credible estimate of the achieved reliability of an equipment design. The paper provides guidance information for the establishment of a RID test requirement for new and overhauled equipment. Management, engineering, and statistical considerations are discussed. A data analysis technique is provided along with examples. Guidelines for interpretation of test and data analysis are discussed. Typical conclusions and recommendations to be drawn from the conduct of a RID test are reviewed.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Ms. Grace A. Marseglia		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
<b>Address:</b> CORADCOM, DRDCO-PT-P, Fort Monmouth, NJ 07703		
<b>Telephone:</b>		
Autovon 995-2205 Commercial (201) 544-2205		

5.4 ENVIRONMENT



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Use of Combined Environmental Reliability Test

**Synopsis:**

ECOM studies show that one of the contributing factors in the difference between the MTBF values observed during contractor testing and those in the field is due to the difference in the environmental conditions under which these values are observed. The Reliability/Maintainability Division of Product Assurance was asked to formulate reliability test environments which would more closely simulate the conditions that the SINGARS-V would see during field use. On the basis of data obtained from Navy, Air Force, and Army sources, PM, SINGARS was provided with combined environmental reliability test conditions which would provide more realistic test results from which management decisions concerning reliability can be made. The combined environmental reliability test conditions included such environmental factors as temperature cycling, vibration, equipment on-off cycling, voltage cycling, humidity cycling, and the introduction of voltage spikes into the test environment. The Air Force has pursued this methodology with some success at the Rome Air Development Center (RADC).

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronic	SINGARS	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. M. Zsak		<input type="radio"/> Conception
<b>Address:</b> CORADCOM Ft. Monmouth, NJ 07703		<input type="radio"/> Validation
<b>Telephone:</b>		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> 995-2754		<input checked="" type="radio"/> Production and Deployment
<b>Commercial</b> (201) 544-2754		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Combined Environments Reliability Test of Re-Test on Inertial Measurement Units

**Synopsis:**

Short-duration (less than 50 hours) Combined Environments Reliability Tests (CERTs) were conducted on eleven Inertial Measurement Units (IMUs), CN-1260/ASN-90(V). These units had been delivered to the depot with a field-reported failure. Extensive IMU performance testing at the depot could not detect any failure, and the units were classified as RTOK (Re-Test OK).

Environmental testing revealed failure modes on seven of the units. The reported field-failure mode was duplicated on five of the units during combined environments testing.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
IMU	CN-1260/ASN-90 (V)	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. D. K. Prather  <b>Address:</b> Air Force Flight Dynamics Lab Wright-Patterson AFB Dayton, OH  <b>Telephone:</b> <b>Autovon</b> 787-5064 <b>Commercial</b> (513) 257-5064		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Demonstration <input checked="" type="radio"/> Production and Support Phase



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Laboratory Simulation of Live Firing Shock

**Synopsis:**

ARRADCOM conducted a program to improve the procedure for developing and executing specification laboratory shock tests of production-type fire control instruments. It was shown that laboratory tests can be developed that satisfactorily simulate the field firing shock environment. The tests can be performed on commercial shock machines using elastic impact pads and require no exotic preparations or procedures. As a result of the program, a laboratory shock test for the M53 sight unit (used with the M29 mortar) was recommended. Since positive and negative responses were shown to be the same, it is not necessary to test in both directions all three instrument axes as is typically required in test specifications. This results in simpler test fixtures and reduced labor costs. Construction of the M29 mortar and the new M224 mortar are sufficiently similar so that the techniques developed for simulating the M29 mortar were used to design the improved shock test procedure for the new M64 sight unit (used with the M224 mortar).

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Weapons	M29 Mortar (M53 sight) M224 Mortar (M64 sight)	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. L. Baker		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment
Address: ARRADCOM Dover, NJ 07801		
Telephone:		
Autovon 880-6741 Commercial (201) 326-6741		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Single Point Vibration Simulation

**Synopsis:**

The Applied Technology Laboratory is concluding the development of an advanced vibration test concept known as force determination, which determines helicopter rotor hub loads (vibratory forces and moments) directly from measured fuselage responses. Included in this endeavor is the development of a method for duplicating or simulating the in-flight vibratory loads and responses measured on a helicopter. This method, known as "ground flying," has been demonstrated to be feasible by laboratory tests and is expected to be relatively simple, inexpensive, reliable, and cost-effective. Its use will allow a rapid accumulation of simulated flight hours in a controllable and monitored environment making it possible that many service failures will be prevented.

Lead-the-fleet testing is anticipated to be another valuable application of this technique. It is estimated that, once perfected, the development cost of a helicopter system will be dramatically reduced.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Helicopter		<ul style="list-style-type: none"><li>● Reliability</li><li>● Availability</li><li>● Maintainability</li></ul>
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. N. Calapodas		<ul style="list-style-type: none"><li>● Conception</li><li>● Validation</li><li>● Full Scale Development</li><li>● Production and Deployment</li></ul>
<b>Address:</b> AVRADCOM Applied Technology Laboratory DAVDL-ATL-ATS		
<b>Telephone:</b> Ft. Eustis, VA 23604		
<b>Autovon</b> 927-5732		
<b>Commercial</b> (804) 878-5732		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Terrain Simulator

## Synopsis:

The terrain simulator is a test simulation device developed to help determine basic equipment design weaknesses that would cause recurring failures during field operation unless engineering fixes or corrections are established. This method was used in analyzing failures experienced by the Army's 5-ton PIP truck.

The terrain simulator was programmed to provide independent inputs to each wheel of the vehicle. The inputs were matched to what the vehicle would experience when operating over a particular field terrain and mission profile. The terrain simulator was used because it provided better control over the test and provided quicker feedback to the RAM and design engineers. Since a preponderance of the vehicle failures are vibration-related, the terrain simulator was an ideal method of testing. The test provided a means of correcting problems in systems before they occur in actual field operation.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Vehicles	5-Ton Truck, M149 Water Trailer, ITV (Improved Tow Vehicle), 1/4-Ton Jeep	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. Ernest E. Marsh		<input type="radio"/> Conception
<b>Address:</b> TACOM RAM Engineering Division (DRDTA-JR)		<input type="radio"/> Validation
<b>Telephone:</b> Warren, MI 48090		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> 273-2860		<input checked="" type="radio"/> Production and Support
<b>Commercial</b> (313) 573-2680		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment

**Date:** August 1979

**Title:** Test Operations Procedure High and Low Temperature Tests of Vehicles, AD-A067422

**Synopsis:**

The procedures for high and low temperature test of vehicles in test chambers and operational conditions, as well as related tests such as temperature shock, are described in a report (AD Number A067422) by TECOM. The report also addresses requirements of MIL-STD-810C and AR-70-38, discusses high and low temperature effects, and provides rationale for test temperatures.

PREVIOUS APPLICATION		
§ 308	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr B. H. Yarborough	<input type="radio"/> Conception
<b>Address:</b>	Army Test and Evaluation Command Aberdeen Proving Ground, MD	<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>	281 94	<input type="radio"/> Production and Development
<b>Commercial</b>	(301) 278-3694	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment/Reliability

**Date:** October 1980

**Title:** Combined Environment Reliability Test (CERT)\*

## Synopsis:

In general, the demonstrated field reliability of a system is lower than the reliability demonstrated in the laboratory. AFFDL conceived the Combined Environment Reliability Test (CERT) to more closely approximate the actual mission profile/environment of the system under test in lieu of the MIL-STD-781 form of reliability testing. Initial test methods and results are discussed.

From the initial tests, two general observations were stated:

- The test approach using a single aircraft mission profile appear to offer more consistency.
- A composite test profile which included qualification test levels appears to offer less consistency. Use of the composite test may be a reasonable engineering test; however, its general applicability must be evaluated.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Dr. Alan H. Burkhard		<input type="radio"/> Conception
Address: Air Force Flight Dynamics Lab. ATTN: AFFDL/FEE		<input type="radio"/> Validation
Telephone: Wright-Patterson AFB, Ohio 45433		<input checked="" type="radio"/> Full Scale Development
Autovon 785-6078		<input type="radio"/> Production and Deployment
Commercial (513) 255-6078		

\*Proceedings, 1977 Annual Reliability and Maintainability Symposium, pp 460-461.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Environment/Reliability

**Date:** July 1980

**Title:** CERT Technology Applied to an Airborne Radar\*

**Synopsis:**

The paper discusses the philosophy of CERT, its benefits, and disadvantages. The Westinghouse CERT facility is described. Based upon a 1,000-hour test of a radar system, the effectiveness of CERT for synergistic failure mode disclosure and reliability growth acceleration is discussed.

During the cited test, synergistic failure modes were not discovered. By subtracting environments, the failure modes which occurred under combined environments were reduced to single-environment. The authors stated that synergistic failure modes are only a small percentage of the failure population. This conclusion agrees with Air Force Flight Dynamics Laboratory findings to date.

A higher reliability growth rate was experienced than could be achieved with sequential single-environment tests. This was a result of more environmentally caused failures occurring and being corrected in a

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Avionics	Radar	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Westinghouse Electric Corporation Product Qualification Laboratory Box 746, MS504 Address: Baltimore, Maryland 21203  Telephone: Autovon Commercial(301) 765-1000		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

\*H. J. Caruso, W. Silver, D. J. Cichetti, D. M. Kubilus; Proceedings, 1979 Annual Reliability and Maintainability Symposiums, pp 131-135; 0149-144X/79/1000-0131.  
5-4-8a

Title: CERT Technology Applied to an Airborne Radar

Synopsis: (Continued)

given period of time.

The author stated that the benefit of CERT is in its cost-effectiveness, reduced test cost, and time.

**5.5 TESTING  
TECHNOLOGY**



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology/Data Analysis

**Date:** November 1980

**Title:** A Method for Automatic Test and Evaluation of Microwave Transceivers at L-Band Frequencies; NRL Memorandum Report 3662; AD-A050442

**Synopsis:**

Complexity of modern phased-array radars requires that new high-speed methods of microwave component test and evaluation be devised, such that not only is the specific device under test evaluated as to quality and accuracy, but also in terms of system errors, the total of all devices is evaluated in an appropriate statistical method to assure final use compatibility. This report summarizes the effort at Naval Research Laboratory, Washington, D.C. to devise such a computer-controlled laboratory test and evaluation facility capable to measuring not only CW devices, such as receivers, but also pulse devices such as transmitters. More specifically, the program, as devised to be implemented in all solid-state L-band transceiver module evaluations, is described.

Samples of computer programs and special test equipment schematics are included, along with samples of data printout. (Author)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronic	L-Band Transceivers	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Louis J. Lavedan, Michael Laing, Boris Scheleg  Address: Naval Research Laboratory Washington, D.C. 20375  Telephone: Autovon 297-2616/3114 Commercial (202) 767-2616/3114		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** November 1980

**Title:** Guidance to Nondestructive Testing Techniques;  
AMCP 702-10, April 1970; AD-728162

**Synopsis:**

The objective of this pamphlet is to provide a reference or guide to nondestructive testing (NDT) techniques/methodology. The following NDT techniques are discussed:

- . Visual
- . Liquid penetrant
- . Magnetic particle
- . X- and gamma-ray film radiography
- . Fluoroscopic and electronic X- and gamma-ray imaging system
- . Sonic and ultrasonic
- . Eddy current
- . Conductivity (electromagnetic)
- . Microwave
- . Infrared
- . Liquid crystal
- . Corona discharge
- . Leak testing

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Mechanical Structural Electronic	NA	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> C. P. Merhib C. A. Darcey	<b>Address:</b> ATTN: DRXMR-MR/MI U.S. Army Materials and Mechanics Research Center Watertown, Massachusetts 02172 <b>Telephone:</b> Autovon 955-3250 Commercial (617) 923-3250	<input checked="" type="radio"/> Conception
		<input checked="" type="radio"/> Validation
		<input checked="" type="radio"/> Full Scale Development
		<input checked="" type="radio"/> Production and Deployment

Title: Guidance to Nondestructive Testing Techniques;  
AMCP 702-10, April 1970; AD-728162

Synopsis: (Continued)

For each technique, the pamphlet provides a discussion of the underlying theory, typical test equipment, typical applications, and any advantages or disadvantages associated with the test method.

For specific applications of NDT methods, or to solve specific test problems, DARCOM users are advised to contact the USAMMRC Nondestructive Testing Branch.

A related pamphlet is AMCP 702-11, Guide to Specifying NDT in Material Life Cycle Applications, November 1970, AD-907111.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** November 1980

**Title:** A Diagnostic Test System for Real-Time Mechanical Wear Assessment

**Synopsis:**

USAMMRC is conducting an investigation into the use of on-line, real-time ferrographic analysis to detect wear particles in lubricant from engines, transmissions, and tail rotor gearboxes. Limited off-line tests have been conducted on lubricants removed from UH-1 and OH-58 helicopters. Results of the ferrographic analysis agreed with those obtained from spectrographic oil analysis.

An on-line, real-time ferrograph has been purchased. This unit was installed on a T-53 engine mounted on a static test stand. After 150 hours of testing, no wear was detected. The engine was disassembled to replace good bearings with worn bearings in an effort to accelerate the wear tests. Testing is continuing.

Future plans are to install an on-line ferrograph in a helicopter and conduct flight tests. Oil from the XM-1 tank engine will be monitored on a bench ferrograph. Use of an on-line ferrograph in the XM-1 will be investigated. (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Lubrication Mechanical Engines Transmissions	UH-1 OH-58 XM-1	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Charles Merhib		<input type="radio"/> Conception
<b>Address:</b> U.S. Army Materials and Mechanics Research Center		<input type="radio"/> Validation
<b>Attn:</b> DRXMR-MR		<input type="radio"/> Full Scale Development
<b>Telephone:</b> Watertown, Massachusetts 02172		<input checked="" type="radio"/> Production and Deployment
<b>Autovon</b> 955-3250		
<b>Commercial</b> (617) 923-3250		

Title: A Diagnostic Test System for Real-Time Mechanical Wear Assessment

Synopsis: (Continued)

Related reports prepared for the Naval Air Engineering Center include:

1. Sample Preparation/Ferrogram Procedure/Ferrogram Analysis  
NAEC-MISC-92-0458, 8 August 1980  
P.M. O'Donnell  
Handling and Servicing/Armament Division  
Ground Support Equipment Department  
Naval Air Engineering Center  
Lakehurst, New Jersey 08733
2. Wear Particle Atlas  
July 1976  
E. R. Bowen, V. C. Westcott  
Foxboro/Trans-Sonics, Inc.  
Burlington, MA 01803
3. Wear Particle Analysis of Grease Samples  
NAEC-92-129, 18 April 1979  
E. R. Bowen, John P. Bowen  
Foxboro Analytical Division  
The Foxboro Company  
Burlington, MA 01803



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** September 1980

**Title:** Establishment of Rapid X-Ray Diffraction  
Inspection Techniques for Residual Stresses;  
TARADCOM-TR-12173; AD-A041147

**Synopsis:**

An automatic stress analyzer has been used by the U.S. Army Tank-Automotive Research and Development Command (TARADCOM) for rapid measurement of residual stresses in track pins and torsion tubes. With this equipment, measurements can be made from 10 to 100 times faster than with conventional equipment. The equipment is a recent development, and few are in existence. A unique feature of the unit at TARADCOM is that it has been interfaced with a computer for purposes of drawing isostress plots.

Work on used track pins showed no detrimental residual stress levels on the surface of the track pins. Measurements taken on sectioned surfaces of track pins revealed areas of tensile residual stress surrounded by compressive residual stresses, with steep stress gradients in between. These areas are in the region between the core and the induction hardened layer; cracking was observed here in laboratory-tested track pins.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Ground Mobile	Track Pins Torsion Tubes	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Salvatore B. Catalano U.S. Army Tank-Automotive Research and Development Command <b>Address:</b> Armor, Material Applications & Technology Functions <b>Telephone:</b> DRDTA-RKA Warren, Michigan 48090 <b>Autovon</b> 273-1101 <b>Commercial</b> (313) 573-1101		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: Establishment of Rapid X-Ray Diffraction Inspection Techniques  
for Residual Stresses  
Synopsis: (Continued)

Vast differences are exhibited in both the isostress plots and the standard deviation of the measurements taken on torsion tubes where failure initiation occurred on the bodies of the tubes, as opposed to instances where failure initiation did not occur in the body of the tube or where failure did not occur at all. These differences may be due to differences in the uniformity of the shot peening operation. Regions of lower compressive residual stress and associated steep stress gradients may act as stress risers and cause premature failure. (Author)



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** August 1980

**Title:** Ultrasonic Nondestructive Inspection of XM650 Rocket-Assisted Projectile in Bonding Quality of the Rotating Band;  
Tech. Memo. ARPAD-MR-77002; AD A042636

**Synopsis:**

Despite the use of hardness and chemical analysis of machining chips and sampling for destructive testing, failures of the copper rotating band of the XM650 rocket-assisted projectile occurred during early development tests. The copper band is a weld overlay whose bonding strength is significantly affected by minor changes in production/manufacturing parameters. A 100 percent inspection procedure was required. C-Scan inspection was selected.

The referenced paper details the establishment of operating parameters and confirmation of the test method by destructive inspection of fired and nonfired shells. A lab standard was developed by drilling three holes (3/16-inch, 1/8-inch, and 1/16-inch in diameter) in the copper band down to the copper/steel interface. It was found that the 1/16-inch hole and the natural flaw pattern in the selected shell were the key to enhancing the inspection procedure. Detection of the natural flaw problem was (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Ordnance	XM650	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Jay S. Pasman Address: U.S. Army Armament Research and Development Command Product Assurance Directorate Picatenny Arsenal Telephone: Dover, N.J. 07801 Autovon 880-5866 Commercial (201) 328-5866		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: Ultrasonic Nondestructive Inspection of XM650 Rocket-Assisted  
Projectile in Bonding Quality of the Rotating Band

Synopsis: (Continued)

extremely sensitive to the test set-up. The inspection procedure was verified through test firings and inspection of the fired shells. Failures of passed shells did not occur.

Development of a grading system and issuance of calibration and operating instructions were discussed. The author's conclusions are as follows:

1. "The ultrasonic C-Scan inspection for rotating band bond quality is a satisfactory and highly repeatable procedure."
2. "Further flight data is required to ensure its value for substitution in lieu of existing destructive testing."
3. "The ultrasonic inspection should be developed further to include other weld characteristics such as maximum penetration, base metal cracking, etc."

A related U.S. Army Materials and Mechanics Research Center (USAMMRC) report is available, which documents the development of this test method and its application to the rotating band problem, in addition to being useful in inspecting tank track pads and graphite epoxy specimens. The report is:

Advanced Acoustic Imaging with  
Linear Transducer Arrays  
James M. Smith  
AMMRC TR77-26, December 1977

U.S. Army Materials and Mechanics Research Center  
Watertown, Massachusetts 02172



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** July 1980

**Title:** NTIAC (Nondestructive Test Information Analysis Center) Handbook

**Synopsis:**

The "NTIAC Handbook" furnishes an overview of state-of-the-art nondestructive test (NDT) methods. The handbook provides a technique guide/selection chart, a bibliography of reference documents and standards, and a directory of organizations involved in NDT.

NTIAC is a DoD information analysis center.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Nondestructive Test Methods		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Nondestructive Test Information Analysis Center		<input type="radio"/> Conception
Address: P.O. BOX 20510 San Antonio, Texas 78284		<input type="radio"/> Validation
Telephone: Autovon		<input checked="" type="radio"/> Full Scale Development
Commercial (512) 684-5111		<input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** July 1980

**Title:** The Inspection of 250,000 M36A2 Percussion Primers by Nondestructive Gamma-Radiation Transmission Gauging; IRT Report 6339-002; April 1980

**Synopsis:**

The M36A2 percussion primer is part of the 30 mm antiarmor projectile utilized by the GAU-8/A cannon. Hangfires cannot be tolerated; therefore, 100 percent inspection of the primers was required. The paper describes the development of a nondestructive test procedure based upon the use of gamma radiation.

IRT initially tried a neutron beam, but found little sensitivity with changes in primer mix weight. Gamma radiation showed better results. A breadboard version of a primer inspection gauging system was produced. The breadboard system was calibrated, and 250,000 primers were inspected. Destructive tests were performed on 70 primers to verify the accuracy of the system.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Munitions	Percussion Primers	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Instrument Research Technology Corp.		<input type="radio"/> Conception
Address: 7650 Convoy Court, P.O. BOX 80817 San Diego, California 12138		<input type="radio"/> Validation
Telephone: Autovon		<input type="radio"/> Full Scale Development
Commercial (714) 565-7117		<input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** August 1980

**Title:** The Use of Microfluorescence Analysis for Process Control in the Semiconductor Manufacturing Industry; 17th/Annual Proceedings-Reliability Physics 1979; pp 190-192

**Synopsis:**

The paper describes a methodology and the equipment to perform the rapid and nondestructive inspection of semiconductor devices for sub-micron organic particulate contaminants. Application of the method to process control is discussed.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Process Control	Semiconductor	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: H. A. Froot  Address: International Business Machine Corp. Data Systems Division Hopewell Junction, N.Y. 12533 Telephone: Autovon Commercial (914) 897-4960		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** September 1980

**Title:** X-Ray Fluorescence Analysis of Composite Propellants for Army Missile Systems; DRDMI-TK-77-5; AD-A044686

**Synopsis:**

Wavelength-dispersive X-ray fluorescence spectrometric procedures were developed for the determination of ingredient percentages and average particle sizes in uncured and cured solid composite propellants of interest in Army missile systems. Three different types of propellant analyses were investigated as follows:

1. The determination of ingredient percentages, with solid particle sizes held constant.
2. The in-situ determination of ammonium perchlorate and aluminum particle sizes, with ingredient percentages held constant.
3. The simultaneous determination of ingredient percentages and solid particle sizes.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Propulsion	Missiles	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Bernard J. Allen  <b>Address:</b> U. S. Army Missile Command Propulsion Directorate, DRDMI-TK Redstone Arsenal, Alabama 35809  <b>Telephone:</b> Autovon 746-7120 Commercial (205) 876-7120		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

**Title: X-Ray Fluorescence Analysis of Composite Propellants for  
Army Missile Systems**

**Synopsis: (Continued)**

The methodology was developed and demonstrated for low-burning-rate polybutadiene acrylic acid-type propellants and high-burning-rate hydroxyl-terminated polybutadiene propellants containing ultrafine ammonium perchlorate. Quantitative procedures were developed for determining ferric oxide, polybutadiene acrylic acid polymer, ammonium perchlorate, and aluminum in polybutadiene acrylic acid propellants, and ammonium perchlorate, aluminum, and a ballistic modifier in high-rate hydroxyl-terminated polybutadiene propellants. The procedures are generally applicable to all types of composite propellants. Emphasis was placed on the establishment of procedures directly applicable to a propellant manufacturing process.

Propellant samples were analyzed nondestructively in most cases with an estimated relative standard deviation and a relative error for ingredient determinations of 1% to 2%. Ultrafine ammonium perchlorate agglomeration in high-rate propellants reduced the precision of aluminum determinations. The estimated relative standard deviation in this case was 4% to 5%. The total analysis time for four replicates of a propellant batch was 15 to 30 minutes with the manual instrumentation used. Multiple linear calibration methods were used to correct for matrix effects. Stable reference standards were used to compensate for instrumental fluctuations; corrections were made for variable emission line absorption by the Mylar films used on the sample holders. Statistical procedures were developed for placing joint confidence intervals on the actual ingredient percentages of a production propellant batch. (Author)



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** August 1980

**Title:** The Detection of Cracks in Ceramic Packages by Vapor Condensation,  
18th Annual Proceedings - Reliability Physics; Las Vegas, Nevada;  
8-10 April 80; pp 59-64

**Synopsis:**

This paper describes the development and application of a non-destructive crack-detection technique for use with ceramic semiconductor packages. The technique is suitable for use in both production-line and failure-analysis applications.

Prior to developing the vapor condensation technique, the author investigated the use of a particle impact noise generator (PIND). Even on severely cracked packages, "sounds" were not heard. Also investigated was the use of various solvents which were applied to the surface of the package and, during the drying process, highlighted the crack. While the technique proved to be sensitive, the approach was discontinued since the test required excessive time (30 to 45 seconds per part) and could not be used on unsealed packages due to possibility of corrosion.

The vapor condensation technique uses FC-77 in a distillation (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronic	Ceramic Semiconductor Package	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Aaron Der Marderosian		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address: Raytheon Company Sudbury, Mass. 01776		
Telephone: Autovon Commercial (617) 443-9521		

Title: The Detection of Cracks in Ceramic Packages by Vapor Condensation

Synopsis: (Continued)

apparatus which is fed nitrogen through an impinger. The vapor is then led through a tube and condensed on the item under evaluation. No special lighting or optical magnification is required. Cracks as fine as 0.1 microns have been detected. The testing rate was 1.5 to 2.0 seconds per device. The average number of devices processed per 8-hour shift per person was 10,000 devices.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** October 1980

**Title:** Development of Nondestructive Testing Techniques for High-Performance Ceramics; AMMRC TR78-11; DLSIE LD# 43282A

**Synopsis:**

The report documents the results of an experimental program conducted as part of the U.S. Army Materiels Testing Technology Program, which evaluated the effectiveness of existing NDE techniques in determining inclusion content in silicon nitride and silicon carbide specially prepared sample billets. The NDE techniques evaluated were radiographics, eddy current, penetrant, and ultrasonics.

The sample billets were seeded with various inclusions. The hot-pressed silicon nitride billets were seeded with tungsten carbide, iron, silicon, and graphite in three nominal sizes (0.13, 0.25, and 0.64 mm). The silicon carbide billets were seeded with iron, silicon, and graphite particles in similar nominal sizes.

Penetrant inspection identified laminations and cracks on the billet surfaces. Eddy current did show some correlation with ultrasonic results; however, eddy current could not be used on the silicon nitride, since this

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Experimental (Gas Turbines)	Turbine blades made of ceramics	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: R. H. Brockelman, G. A. Parcy  Address: U.S. Army Materiels and Mechanics Research Center Watertown, Massachusetts 02172  Telephone: Autovon 955-3250 Commercial (617) 923-3250		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

**Title: Development of Nondestructive Testing Techniques for  
High-Performance Ceramics**

**Synopsis: (Continued)**

material is a nonconductor.

Ultrasonics (C-scan) and radiographics were used to characterize the billets, after which the billets were cut into blanks for use in fracture (bend strength) testing. Bend strength testing was conducted to evaluate the effect of inclusions upon material strength.

The following table was provided in the report summary.

<u>Matrix Material/Defect Type</u>	<u>Nominal Defect Size</u>		
	<u>Fine</u>	<u>Medium</u>	<u>Coarse</u>
NC-13Z HPSN; Fe	X, U	X, U	X, U
NC-13Z HPSN; Wc	X, U	X, U	X, U
NC-13Z HPSN; Si	U	U	X, U
NC-13Z HPSN; C	-	U	X, U
NC-43T SiC; C	U	U	X, U
NC-43T SiC; S	-	U	U

X = Radiograph, U = Ultrasonic

From the table it is evident that ultrasonics was more capable of detecting a wider range of inclusion sizes.

The conclusions of the study stated that the evaluated NDE methods can reliably detect the type of large defects/inclusions which may be experienced during the manufacturing process. The lower limit of reliable NDE was not established during the study. This limit needs to be defined, since inclusions smaller than 100 micrometers can affect material strength.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** August 1980

**Title:** Radiography of Partial-Penetration Welding for the 155MM M198 Towed Howitzer, M39 Carriage

**Synopsis:**

Radiography of partial-penetration welds and resolution of radiographic inspection requirements were determined, utilizing, in some areas, state-of-the-art radiographic techniques. The objective of this effort was establishment of criteria for each weld of the carriage.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Leary G. Baker  <b>Address:</b> ARRADCOM Product Assurance Directorate Dover, NJ 07801  <b>Telephone:</b> <b>Autovon</b> 680-6741 <b>Commercial</b> (203) 328-6741		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** October 1980

**Title:** Failure Analysis Using Scanning Electron Microscopes

**Synopsis:**

Positive identification of cause of failures allows intelligent analysis of significance of problems and confidence in corrective actions.

The ARRADCOM failure-analysis laboratory has high-technology equipment and procedures not available to typical bench engineers. Utilizing the scanning electron microscope failures due both to electrical and mechanical components has been successfully resolved by ARRADCOM personnel.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Lance Gyroswitch	Electromechanical device	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Lance Fuze	Electronic components	
Lance Cutting Network	Explosive network	
M105 Propelling Charge	Nitrocellulose structure	
483 ICM Round	Lead cup weld	
S&A electronics		
Point of Contact		Life Cycle Phase
Name:	Phillip E. Houser	<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address:	US Army Armament R&D Command ATTN: DRDAR-LCA-PD Dover, NJ 07801	
Telephone:		
Autovon	880-2679	
Commercial	(201) 328-2679	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** November 1980

**Title:** A Circular Transducer Array for Ultrasonic Inspection of Plates and Sheets; NRL Report 8119; AD-A041422

**Synopsis:**

To reliably detect and evaluate randomly oriented plate flaws, the object under test must be inspected at many angles. Several years ago NRL developed an ultrasonic transducer fixture, which mechanically rotated a transducer in a circular pattern. Due to the weight of the drive mechanism, the transducer mechanism proved to be impractical. NRL then proceeded to develop a transducer assembly consisting of seven transducers, angled to produce 45° shear waves in steel, arranged in a circle, plus a center transducer. Switching is accomplished electrically.

The reference report furnishes circuit schematics, as well as test results.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Structural		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: K. F. Simmonds S. D. Hart Address: Naval Research Laboratory Washington, D.C. 20575 Telephone: Autovon 297-3094/3613 Commercial (202) 767-3094/3613		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** December 1980

**Title:** Aerostructure Nondestructive Evaluation by Thermal Field Techniques,\*  
NAEC-92-131

**Synopsis:**

Infrared thermography shows considerable promise as a method to rapidly detect flaws in large aerostructural surfaces. Ultrasonic detection offers high resolution reliability but entails a time-consuming scanning procedure. Thermography permits the rapid scanning of large surfaces but with a loss of information (less resolution than ultrasonics). The objective of the reported effort was to develop a thermographic technique which would rapidly scan the surface under evaluation and detect potential flaw sites. More precise NDE techniques (e.g., ultrasonics) would then be utilized to evaluate the potential flaw site.

The investigations induced temperature gradients in the test specimens by the externally applied heat and stress cycling methods. Defects were induced into test specimens (which duplicated typical aerostructures) constructed from laminated graphite/epoxy (Gr/Ep), boron/epoxy (B/Ep), glass/epoxy (Gl/Ep), and 6061-T6 aluminum (Al).

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> P. V. Ciekurs  Commanding Officer <b>Address:</b> Naval Air Engineering Center Attn: 92724 Lakehurst, New Jersey 08733 <b>Telephone:</b> Autovon 624-7464 Commercial (201) 323-7464		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

\*Prepared by Dr. P. V. McLaughlin, Jr. and Dr. E. V. McAssey, Jr., Villanova University, Department of Mechanical Engineering, Villanova, PA 19085.

Title: Aerostructure Nondestructive Evaluation by Thermal Field Techniques

Synopsis: (Continued)

The experiments utilized an AGA Thermovision System 680/102B infrared camera and both a black-and-white and color isotherm video read-out. The color display provides 10 subranges of temperature read-out.

The following conclusions were stated:

- 1) Infrared thermography must be considered a strong candidate as an NDE tool in aviation maintenance.
- 2) The externally applied heat technique was successful with Gr/Ep, Gl/Ep, B/Ep, and Al materials.
- 3) Stress-induced temperature gradients were observed in Gl/Ep specimens at cycle frequencies as low as 1 Hz and 0.05 of static ultimate load. No heat was generated in Gr/Ep and Al specimens. Heat was generated, however, in axially cracked Gr/Ep specimens at the crack surface.
- 4) Surface reflectivity and conductivity can affect results. Painted surfaces reduce spurious reflections.
- 5) Additional work is required to define the range of flaw types and extent of flaw damage which can be reliably detected.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** December 1980

**Title:** Application of Pattern Recognition and Minicomputer Technology to Ultrasonic Inspection

**Synopsis:**

The Naval Air Engineering Center is conducting an investigation to improve the reliability of ultrasonic inspections of aircraft structures. The approach adopted by the investigators utilizes an operator-computer interactive scheme based upon the latest ultrasonic inspection techniques, pattern-recognition algorithms, and minicomputer technology.

The following NAEC reports have been generated as part of this effort:

- 1) An Adaptive Accept-Reject Module for Transducer Evaluation and Potential Flow Classification Applications

NAEC-GSED-121, 21 July 1978

Dr. J. L. Rose, G.P. Singh

Drexel University

Mechanical Engineering and Mechanics Department

Philadelphia, Pa. 19104

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> P. V. Ciekurs  <b>Address:</b> Commanding Officer Naval Air Engineering Center ATTN: 927248  <b>Telephone:</b> Lakehurst, New Jersey 08733 <b>Autovon</b> 624-7464 <b>Commercial</b> (201) 323-7464		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: Application of Pattern Recognition and Minicomputer Technology  
to Ultrasonic Inspection

Synopsis: (Continued)

2) Generalized Approach to New Problems in Ultrasonic  
Inspection (GANPUI)

NAEC-92-140, 2 April 1980

Dr. J. L. Rose, J. J. Avioli

Drexel University

Mechanical Engineering and Mechanics Department

Philadelphia, Pa. 19104



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** December 1980

**Title:** N-Ray Inspection of Aircraft Structures Using Mobile Sources:  
A Compendium of Radiographic Results;\* NAEC-92-116

**Synopsis:**

This report is a compendium of the results of neutron radiographic inspections performed on aircraft thin and thick metal laminates and composite-to-metal structures. The neutron sources utilized in the study were Californium-252 isotope, a Van de Graaff accelerator, and a reactor used in a mode which simulated the beam geometry of a mobile system.

The investigator stated the following conclusions:

- 1) The resolution and sensitivity of state-of-the-art mobile N-ray systems are adequate for effective nondestructive inspection of aircraft for many commonly occurring defects.
- 2) Radiographic results from such systems included in the compendium clearly demonstrate the validity and power of the technique.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: P. V. Ciekurs Commanding Officer Address: Naval Air Engineering Center Attn: 92724 Lakehurst, New Jersey 08733 Telephone: Autovon 624-7464 Commercial (201) 323-7464		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

\*Prepared by Dr. W. E. Dance, Vought Corporation, P.O. Box 226144, Dallas, TX 75266.

Title: N-Ray Inspection of Aircraft Structures Using Mobile Sources:  
A Compendium of Radiographic Results; NAEC-92-116

Synopsis: (Continued)

- 3) The systems utilized in the exploratory work which provided these results have proved the feasibility of making N-ray systems sufficiently portable to inspect aircraft structures.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** November 1980

**Title:** Use of FFT/IR in Cure Analysis; Tri-Service Symposium: In-Process Quality Control for Non-Metallic Materials; 30 April-1 May 1980, Albuquerque, N.M, pp 77-92

**Synopsis:**

While the range of military applications of fiber-reinforced epoxy resin composite structures has increased significantly, NDE methods have not advanced. USAMMRC developed a Fast Fourier Transform (FFT) infrared (IR) spectroscopy technique to determine the state-of-cure in fiber-reinforced epoxy resin composites. Two commercial resins (RAC 7250 and SP 250) were studied under different curing conditions.

The USAMMRC experiments consisted of curing the films of neat resin in the sample compartment of a Digital Model FTS-10M FT-IRS. While the resin cured, the infrared spectrum from 3,800 to 450 wave numbers was measured at one-minute intervals. The extent of cure was monitored by measuring the epoxy ring absorbance at approximately 915 wave numbers (the exact location must be determined for epoxy resin being analyzed). As the cure proceeds, the intensity (amplitude) of the absorbance at 915 wave number decreases.

The infrared spectra for prepreg and composite samples were made (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Composites NDE	Fiber-Reinforced Epoxy Resin Infrared Spectroscopy	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Dr. J. Sprouse/Dr. B. Halpin, Jr.  Address: US Army Materials and Mechanics Research Center Watertown, Massachusetts  Telephone: Autovon 955-3000 Commercial (617) 923-3000		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: Use of FFT/IR in Cure Analysis

Synopsis: (Continued)

using a Harrick Model 4X-TBC-VA internal reflectance spectroscopy attachment.

USAMMRC found that FT-IRS offers an excellent technique for fiber-reinforced epoxy composites and neat resins. Specific findings regarding the RAC 7250 and SP 250 composites were as follows:

- . Complete epoxide ring opening was not achieved on the RAC 7250 samples during a two-hour cure at 127°C. Only 70 to 80 percent was achieved. The remaining percentage can be reacted by subjecting the sample to 200°C; however, excessive thermal oxidation of the resin will result.
- . The SP 250 samples experienced complete cure during the two-hour period at 127°C.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** TEST/Testing Technology

**Date:** December 1980

**Title:** Acoustic Emission as an NDE Technique for Determining Composite Rotor Blade Reliability; AD-A090440

**Synopsis:**

AMMRC and ATL are investigating the use of the acoustic emission (AE) NDE technique for detecting flaw initiation and growth in composite rotor blades. AE has been extensively used in the past as NDE technique to assess the structural integrity of reinforced plastic components (e.g., plastic storage tanks).

While testing is continuing, early results indicate that AE can detect minor fatigue damage. The authors believe it is possible to project an AE failure curve based on the emissions from periodic overloads. AE, with vibrothermography as a complementary NDE technique, appears to be excellent for use in detecting, locating, and characterizing flaws.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Helicopter	Rotor Blades	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> R. J. Shuford; W. W. Houghton  <b>Address:</b> Commanding Officer Army Materials and Mechanics Research Center  <b>Telephone:</b> Watertown, MA 02172 <b>Autovon</b> 955-3000 <b>Commercial</b> (617) 923-3000		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

Title: Acoustic Emission as an NDE Technique for Determining Composite  
Rotor Blade Reliability; AD-A090440

Synopsis: (Continued)

The AE technique should find application in both initial certification and in-service inspection. In the field, the rotor blades could be proof-tested, and an estimate of the remaining service life could be generated.

6. ANALYSIS

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Q.1 DATA



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Data

**Date:** August 1979

**Title:** TAERS Data Reduction and Analysis Computer Program;  
AMSAA TR-141; AD-A018530

**Synopsis:**

The Army Equipment Record System (TAERS) is a data bank that contains operational and maintenance histories of Army equipment.

To facilitate the use of this system, a series of computer programs has been developed to extract, decode, reduce, correct, and analyze the TAERS columnization of pertinent data items; order histories by date; correct each history with a single mileage discrepancy; delete each history with multiple mileage errors; eliminate portions of histories with intermittent quarterly reporting; examine stock numbers and quantities of parts replaced; summarize by individual vehicle the odometer readings, dates, maintenance actions, and man-hours reported in each history; and determine RAM characteristics, maintenance costs, and total parts usage for each vehicle series.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Vehicles Helicopters	M35A2, M39A2, M151A1 H-1G, H-47, H-54, OH-58, UH-1A	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. W. Hirnyck	<b>Address:</b> AMSAA-DRXS-Y-R Aberdeen Proving Ground, MD 21005	<input type="radio"/> Conception
<b>Address:</b>		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 283-4291 <b>Commercial</b> (301) 278-4291		<input checked="" type="radio"/> Production and Deployment

Title: TAERS Data Reduction and Analysis Computer Program

Synopsis: (Continued)

The programs are written in FORTRAN IV with some nonstandard features. Standardized versions of most of the programs exist, conforming to ANSI X3J3/77 (proposed). The programs are documented in AMSAA TR-141, which is available from DDC with accession number AD-A018530.

6-1-1b



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Data

**Date:** August 1979

**Title:** Tube Reliability and Failure Logistics Data Base (LOG DB)

**Synopsis:**

The Night Vision and Electro-Optics Laboratories have recently established the Tube Reliability and Failure Logistics Data Base (LOG DB). This data base has been established to store data consisting of key parameters for all 18 mm second-generation image-intensifier tubes delivered in AN/PVS-5 and AN/PVS-5A Night Vision Goggles Systems. Data on tubes delivered as spares are also included. The data are accumulated by two methods. First, initial tube data are received monthly from the tube production contractors. Second, data are received monthly from the Sacramento Army Depot on tubes and goggles received from the field for repair and refurbishment.

Initially, this system consisted of over 13,300 individual Image Intensifier Tube Assemblies (IITA). Now, for the first time, a vehicle for tracking such items as statistics on tube characteristics, the most prominent failure modes in the field, the most prominent missing items on goggles returned from the field, and the average field usage of tubes (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronic	AN/PVS-5, AN/PVS-5A	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. D. Morella		<input type="radio"/> Conception
<b>Address:</b> ERADCOM - Night Vision Lab Ft. Belvoir, VA 22060		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 354-5291		<input checked="" type="radio"/> Production and Deployment
<b>Commercial</b> (202) 664-5291		

Title: Tube Reliability and Failure Logistics Data Base (LOG DB)

Synopsis: (Continued)

is provided. This analysis can provide valuable information in determining the future specifications and procurement requirements for spare tubes and system components. It can also be used to produce the necessary analysis to locate logical support problems in the field.

LOG DB has similar applications in various other systems, tracking the characteristics of specific parts.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Data

**Date:** August 1979

**Title:** Vehicle Technical Management Information System (VETMIS)

**Synopsis:**

VETMIS is a real-time data bank system that supplies information on Army vehicle life cycles, technical performance, engineering analysis, and maintenance data. The system consists of data modules containing information such as test, laboratory, field, and inspection data, disposal data, cost data, and the Test Interactive Management System (TIMS) data. The TIMS data module provides status of testing schedules, funding, delivery of materials, spare parts, and maintenance packages. The present VETMIS system is a remote computer facility at ARRADCOM tied to interactive terminals located at TARADCOM Product Assurance Directorate and TARCOM Maintenance Directorate.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Vehicle		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. W. Simkovitz		<input checked="" type="radio"/> Conception
<b>Address:</b> TACOM RAM Engineering Division DRDTA-JR		<input checked="" type="radio"/> Validation
<b>Telephone:</b> Warren, MI 48090		<input type="radio"/> Full Scale Development
<b>Autovon</b> 273-2860		<input type="radio"/> Production and Support
<b>Commercial</b> (313) 573-2860		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Data

**Date:** August 1979

**Title:** Non-Parametric Methods in Investigating Weapon Durability

**Synopsis:**

In making proper statements about a system's life distribution, a distribution of time to extinction must be defined. It is possible to make statements about a life distribution in the absence of a distribution assumption, but confidence statements about the mean require a sample large enough to justify the use of a normal approximation. In general, the costs associated with durability testing limit the test program so that a large sample approximation cannot be used, and available data are insufficient to validate the assumption of a distributional form.

Procedures have been developed for estimating bounds on confidence limits for certain parameters of distributions with monotone (increasing or decreasing) hazard rate on the basis of truncated experimental data. The procedures rest on certain inequalities relating the properties of arbitrary monotone hazard rate distributions to the properties of

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Weapons	Machine Gun	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. W. Eissner		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address: AMSAA-DRXSY-R Aberdeen Proving Grounds, MD 21005		
Telephone: Autovon 283-4064 Commercial (301) 278-4064		

Title: Non-Parametric Methods in Investigating Weapon Durability

Synopsis: (Continued)

exponential distributions. The inferences possible with these methods are the best possible with the monotone hazard rate assumption.

Computer programs have been written to compute and plot bounds for operating characteristic curves of time-truncated tests.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Data

**Date:** August 1979

**Title:** A Method for Adjusting Maintenance Forecasts to Account for  
Planned Aircraft Sortie Lengths

**Synopsis:**

A technique has been developed for adjusting forecasted failure rates of developmental aircraft systems to account for the effect of the planned sortie lengths of the new aircraft. This technique utilizes maintenance data collected from the current inventory of comparison operational systems. After all other factors have been scrutinized, the failures resulting in maintenance actions are plotted against average sortie lengths. Then linear regression is used to smooth chance variation, and the intercept is related to cyclic or warm-up failure rates, while the slope is related to time-induced failures. This technique was used to analyze failure rates for four aircraft types (three military and one civilian). Comparisons were made, and it was recommended that this technique be used in forecasting failure rates of developmental military aircraft systems.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. L. D. Howell	<input type="radio"/> Conception
<b>Address:</b>	Headquarters, Air Force Logistics Command	<input type="radio"/> Validation
	Aeronautical Systems Division	<input type="radio"/> Full Scale Development
<b>Telephone:</b>	Wright-Patterson AFB, OH	<input type="radio"/> Production and Deployment
<b>Autovon</b>	787-3013	
<b>Commercial</b>	(513) 257-3013	

62 LIFE CYCLE



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Life Cycle

**Date:** August 1979

**Title:** Useful Life Methodology

**Synopsis:**

In view of the large amount of funds spent for vehicle procurement, a method has been developed for ascertaining what the lives of the various fleets of vehicles should be.

AMSAA has developed a method for evaluating the useful life of Army trucks. Its purpose is to determine the age (military) at which it becomes economical to replace the trucks and to determine the economics of overhauling the fleet to extend its life and the remaining life after overhaul. Two data sources consisting of The Army Equipment Record System (TAERS)/The Army Maintenance Management System (TAMMS) and the Sample Data Collection (SDC) are used to compile maintenance data.

As a result of the application of this method, the useful lives of various Army trucks have been extended significantly, resulting in substantial cost savings.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Vehicles	1/4, 1-1/4, 2-1/2, and 5-ton trucks	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. Bell	<b>Address:</b> AMSAA-DRXS-RE Aberdeen Proving Grounds, MD 21005	<input type="radio"/> Conception
<b>Address:</b>		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 283-2135 <b>Commercial</b> (301) 278-2135		<input checked="" type="radio"/> Production and Deployment

Title: Useful Life Methodology

Synopsis: (Continued)

To implement this method, a large amount of data is required to determine maintenance cost as a function of accumulated mileage. Field data collection efforts or special tests can provide such data.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Life Cycle

**Date:** August 1979

**Title:** Multivariate Classes in Reliability Theory; AD-A069308

**Synopsis:**

Four classes of lifetimes which have been useful in describing situations where systems are assumed to have independent univariate component lifetimes are: the increasing failure rate (IFR) class; the increasing failure rate average (IFRA) class; the new better-than-used (NBU) class; and the new better-than-used-in-expectation (NBUE) class. These classes have been reviewed, and multivariate analogs of the IFR and IFRA cases are discussed in Report AD A069308. New multivariate definitions of NBU and NBUE are also introduced.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. H. W. Block	<input type="radio"/> Conception
<b>Address:</b>	Department of Mathematics and Statistics	<input type="radio"/> Validation
	Pittsburgh University	<input type="radio"/> Full Scale Development
<b>Telephone:</b>	Pittsburgh, PA	<input type="radio"/> Production and Deployment
<b>Autovon</b>		
<b>Commercial</b>	(412) 624-4141	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Life Cycle

**Date:** October 1980

**Title:** Aviation Sample Data Collection

**Synopsis:**

Recognizing the need for a life-cycle data base for evaluation of RAM and logistics support of Army aircraft, TSARCOM developed and implemented the Unscheduled Maintenance Sample Data Collection Program for all first-level aircraft.

The system was designed to be compatible with the RAM/LOG data base developed during test and provide the degree of quality and timeliness which could be obtained through the normal TAMMS free-flow data.

The use of on-site field monitors at selected sample units, an accurate and usable data base, is being generated, supporting RAM improvement of current aircraft and providing necessary baseline data for use in future development.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Aircraft	AH-1, UH-1, CH-47, OH-58, OV-1, UH-60	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. Robert Vodicka		<input type="radio"/> Conception
Address: TSARCOM - DRSTS-QSM(2) St. Louis, MO 63120		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon 693-0290		<input checked="" type="radio"/> Production and Deployment
Commercial (314) 263-0290		

0.3 RELIABILITY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Reliability

**Date:** August 1979

**Title:** Reliability Analysis of Complex Systems

**Synopsis:**

A reliability analysis technique that can be applied to complex systems involves the use of a computer program that calculates the probability of system performance as a function of time.

This technique uses a computer program developed by Kaman Sciences Corporation as a tool for the safety and reliability analysis of an anti-missile system. Early versions of the program were used extensively by the mathematicians of Nuclear Systems Division. Since that time Kaman has used the program in other applications, notably nuclear-fueled power systems, and it has been added to and revised many times in the years since.

The output of the program is a table of the probabilities of the time occurrences of a number of selected events related to the system. A typical event would be the detonation of a weapon as a function of the self-destruct of a weapon. The ability to give the probability of (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Missiles	SPRINT, SPARTAN	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. P. Olivieri		<input checked="" type="radio"/> Conception
<b>Address:</b> ARRADCOM ATTN: DRDAR-QAN Dover, NJ 07801		<input checked="" type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 880-3864		<input type="radio"/> Production and Deployment
<b>Commercial</b> (201) 328-3864		

Title: Reliability Analysis of Complex Systems

Synopsis: (Continued)

certain final events in all time points in which such a probability exists enables both reliability and safety to be analyzed simultaneously.

The analysis will be as complete as the model of the system will allow. Many of the ARRADCOM systems can be modeled directly from the schematic diagram, with GO-type components representing system components and operations. The model can often be visually very similar to the schematic. As in any real-life circuit, the output from or event occurrence of any component is determined probabilistically from the inputs from previous components and signals introduced from program input.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Reliability

**Date:** August 1979

**Title:** Reliability Growth Management, MIL-HDBK-189

**Synopsis:**

Not until the last few years has the formal management method for planning, assessing, and controlling the reliability growth process been available to program managers. The Department of the Army has enjoyed considerable success in managing reliability growth as a result of applying the AMSAA growth model. Army experience has shown that reliability growth technology has reached a level of development which is statistically sound and reasonably adequate to the tasks. It has generated a considerable payoff in the form of an increased rate of reliability improvement in development. However, the understanding of reliability growth concepts and techniques varies between commands and in project manager organizations.

Because of the diverse and complex nature of managing a reliability growth program, there exists a need for the Department of Defense to implement detailed guidelines regarding reliability growth policies for planning and assessing system reliability during development. AMSAA has developed a MIL-HDBK standardization handbook which satisfies this need. (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Various	Blackhawk, XM1, TSQ-73 Patriot	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Dr. L. Crow		<input type="radio"/> Conception
<b>Address:</b> AMSAA-DRXSY-RE Aberdeen Proving Grounds, MD 21005		<input type="radio"/> Validation
<b>Telephone:</b>		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> 283-5882		<input checked="" type="radio"/> Production and Deployment
<b>Commercial</b> (301) 278-5882		

Title: Reliability Growth Management, MIL-HDBK-189

Synopsis: (Continued)

In consonance with MIL-HDBK-189, the reliability growth model employed by AMSAA provides a means for tracking the progress of a reliability program by using data generated during development testing. The use of cumulative data has reduced requirements for current test data. Provisions have been made for the case in which failures are detected during inspection rather than at the exact time of occurrence. Output from computer programs includes maximum likelihood estimates of the two parameters defining the reliability growth curve, point estimates of the current and projected MTBFs, confidence interval estimates of MTBF, and goodness-of-fit tests.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Reliability

**Date:** August 1979

**Title:** A Bayesian Nonparametric Approach to Reliability

**Synopsis:**

It is suggested that problems in a reliability context may be handled by a Bayesian nonparametric approach. A stochastic process is defined, whose sample paths may be assumed to be either increased hazard rates or decreasing hazard rates by properly choosing the parameter functions of the process. The posterior distribution of the hazard rates are derived for both exact and censored data. Bayes estimates of hazard rates, CDFs, densities, and means are found under squared-error-type loss functions. Some simulation work was done and estimates graphed to better understand the estimators. Finally, estimates of the CDF from some data in a paper by Kaplan and Meier were constructed.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. R. L. Dykstra	<input type="radio"/> Conception
<b>Address:</b>	Department of Statistics Missouri University Columbia, MO	<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Deployment
<b>Commercial</b>	(314) 882-2121	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Reliability

**Date:** August 1979

**Title:** A Redundancy Notebook; AD-A05083

**Synopsis:**

The objective of the notebook is to present in a coherent fashion the information and tools necessary for the evaluation of most types of redundancy design configurations with which a reliability engineer is faced. The report contains a number of alternative evaluation approaches, both classical and unique, for the evaluation of the reliability of various types of redundant configurations.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. K. Lion  <b>Address:</b> Rome Air Development Center Griffiss AFB, NY  <b>Telephone:</b> Autovon 587-1110 Commercial (315) 330-1110		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Reliability/Availability

**Date:** May 1980

**Title:** Methodology for Estimating Mission Availability and Reliability for a Multimodal System; AMSAA-TR-297; AD-A087755

**Synopsis:**

Reliability and operational availability estimation techniques are developed for systems having several modes of operation and whose reliability and operational availability requirements have been set for a particular mission profile. An example of the application of these models is also included.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. H. Betz Director, U.S. Army Materiel Systems Analysis Activity <b>Address:</b> Attn: DRXS-Y-RE Aberdeen Proving Grounds, MD 21005 <b>Telephone:</b> Autovon 283-2135 Commercial (301) 278-2135		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

AVAILABILITY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Availability

**Date:** August 1979

**Title:** General Model (GENMOD)

**Synopsis:**

GENMOD is a user-oriented computer program to analyze the design and performance characteristics of automated production lines. It was developed by the Product Assurance Directorate of ARRADCOM in response to a need to model various automated production lines to study the adequacy of design and the effects of proposed design changes. The program has been used by various organizations to successfully model a wide variety of lines.

Because the program was set up as a generalized modeling system, the user needs no knowledge of programming, but rather a thorough knowledge of the line design and an ability to categorize its operations by a proper building block. Once the model is developed, it is punched from a simple coding form and is fed to the program as data, with no need to alter the program itself. The development of GENMOD is a continuing effort, with updates and refinements continually being made to the program.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Production Line		<input type="radio"/> Reliability <input checked="" type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:	Mr. E. Loniewski	<input type="radio"/> Conception
Address:	ARRADCOM P&A Directorate Dover, NJ 07801	<input type="radio"/> Validation
Telephone:		<input checked="" type="radio"/> Full Scale Development
Autovon	880-5817	<input checked="" type="radio"/> Production and Deployment
Commercial	(201) 328-5817	

Title: General Model (GENMOD)

Synopsis: (Continued)

The prime output from the program is an evaluation of the ability of the model to produce a project at a particular rate under particular operating conditions. Secondary outputs include buffer utilization and machine utilization analyses.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Availability

**Date:** August 1979

**Title:** Analyzing Availability and Readiness Using Transfer Function Models and Cross-Spectral Analysis

**Synopsis:**

Methods of multivariate time series analysis can be used in a novel way to investigate the interrelationships between a series of operating (running) times and a series of maintenance (down) times of a complex system. Specifically, the techniques of cross-spectral analysis help to obtain a Box-Jenkins-type transfer function model for the running times and the down times of a nuclear reactor. A knowledge of the interrelationships between the running times and the down times is useful for an evaluation of maintenance policies, for replacement policy decisions, and for evaluating the availability and the readiness of complex systems.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>	Mr. N. Singpurwalla	<input type="radio"/> Conception
<b>Address:</b>	Inst. for Management Science and Engineering	<input type="radio"/> Validation
<b>Telephone:</b>	George Washington University	<input type="radio"/> Full Scale Development
<b>Autovon</b>	Washington, DC	<input type="radio"/> Production and Deployment
<b>Commercial</b>	(202) 676-6083	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Availability

**Date:** August 1979

**Title:** The Availability and Effectiveness of Modular Systems

**Synopsis:**

Most large computer systems can be regarded as being constructed from a number of independent subunits, each of which has a characteristic mean time between failures and mean time to repair. A method of calculating the probability that such a system is in a fully operational state, or in any one of the possible failure states, at any given instant has been developed. If it is possible to ascribe effectiveness to the system in its various failure states as well as to the fully operational state, this information can be combined with the results of the probability calculations to give a system-effectiveness plot. Such plots can be used to compare the availability expected from different system designs.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. D. S. Hill		<input type="radio"/> Conception
<b>Address:</b> Signals Research and Development Establishment		<input type="radio"/> Validation
<b>Telephone:</b> Christ Church, England		<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Deployment
<b>Commercial</b>		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Availability

**Date:** August 1979

**Title:** Availability-Reliability Analysis

**Synopsis:**

This simulation method analyzes the reliability of basic equipment, including Government-Furnished Equipment (GFE), taking into consideration its availability, maintainability, operational profile, and mission reliability. The analysis will determine probabilities of success on the basis of these parameters. These probabilities can be used to determine a realistic system reliability requirement and can be used in identifying areas where reliability is not satisfactory.

This has proven useful as a model using real data in evaluating RAM requirements, identifying weak assemblies, and identifying contractual performance requirements.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronic Helicopters	TACFIRE, TSQ-73, BLACKHAWK	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. McGauley Chief, RAM Division		<input type="radio"/> Conception
<b>Address:</b> U.S. Army Materiel Systems Analysis Activity		<input type="radio"/> Validation
<b>Telephone:</b> Aberdeen Proving Grounds, MD 21005		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> 283-4495		<input checked="" type="radio"/> Production and Deployment
<b>Commercial</b> (301) 278-4495		

AS MAINTAINABILITY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Maintainability

**Date:** August 1979

**Title:** Soft-Core Mock-Up Maintainability Assessment

**Synopsis:**

The Project Manager for the CH-47 modernization is conducting a maintainability program that is oriented toward making early decisions on the helicopter design. The maintainability effort on this helicopter is not an analytical process. Soft-core mock-ups (full-scale models fabricated from panels of kraft-paper-covered styrofoam) have been used extensively to force an early consideration of maintainability. An actual working model would remove the abstract element from maintainability. When used by experienced maintainability engineers and designers, the soft-core mock-ups permit a direct and virtually immediate evaluation of all proposed design changes. The use of this system has improved maintenance of the Auxiliary Power Unit (APU) installed in the upper portion of the aft pylon. The existing aircraft require two individuals to support and maneuver the APU when removing it. The new design requires only one individual to guide the APU. Other changes that have been made include repositioning the oil filter to provide clearance between the filter and the aircraft skin.

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Helicopters	CH-47	<input type="radio"/> Reliability <input type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. Shannon		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
<b>Address:</b> Project Manager, CH-47 AVRADCOM-DRCPM St. Louis, MO 63166		
<b>Telephone:</b>		
<b>Autovon</b> 693-1411 <b>Commercial</b> (314) 263-1411		

Title: Soft-Core Mock-Up Maintainability Assessment

Synopsis: (Continued)

The "Dirty Rag Mechanic" concept is an analysis based on inputs from personnel directly involved with a system's maintenance. This concept has been used to get the benefit of the experience of Army personnel who are using the present CH-47. At the present time, three design changes have been implemented as a direct result of the "Dirty Rag Mechanic" review, and an additional half-dozen are pending.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Maintainability

**Date:** August 1979

**Title:** Maintainability Prediction and Analysis

**Synopsis:**

Existing maintainability prediction techniques are not accurate estimators of current electronic equipment/system characteristics. A new time-synthesis prediction technique was developed which directly relates diagnostic/isolation/test subsystem characteristics and other design characteristics to equipment/system maintainability parameters. The developed methodology includes a detailed prediction procedure for use when final design data are available and an early prediction procedure for use when preliminary design data are available. Predicted parameters include mean time to repair, maximum (percentile) time to repair, maintenance man-hours per repair, and fault-isolation resolution. A comprehensive set of time standards applicable to physical maintenance actions associated with current construction and packaging techniques is available.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. T. Pliska  <b>Address:</b> Hughes Aircraft Co. Fullerton, CA  <b>Telephone:</b> Autovon Commercial (714) 732-3232		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Maintainability

**Date:** August 1979

**Title:** Operational Influences on Maintainability; AD-A042983

**Synopsis:**

The results of a study of the operational influences on the field maintainability of USAF ground electronic equipment are documented in the referenced report. The study identifies operational factors which contribute to the increase in field equipment mean time to repair (MTTR) from values estimated during equipment development. A checklist-type model is included in the report which can be used to estimate the field MTTR given a maintainability prediction and knowledge of the influencing factors.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. L. Phaller		<input type="radio"/> Conception
<b>Address:</b> Westinghouse Defense and Electronics Systems Center Baltimore, MD		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Deployment
<b>Commercial</b> (301) 765-1000		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Maintainability

**Date:** August 1979

**Title:** The First Time a Separately Maintained Parallel System Has Been 'wn for a Fixed Time

**Synopsis:**

A system that works for a random time when failed is fixed in a length of time that is also random. This is an important factor in the study of the first time the system is not working for an interval of time longer than some prespecified value. For instance, in a nuclear reactor, when the safety system is out for some critical time, it is necessary to shut down the complete system with all the problems this entails. In the food industry, where food must, in general, be kept at a certain temperature, an important question when the refrigeration system goes down is how long this situation can be maintained before the food becomes spoiled. This study considers a system consisting of separately maintained, independent components where the components alternate between intervals in which they are "up" and in which they are "down".

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. S. M. Ross		<input type="radio"/> Conception
<b>Address:</b> Operations Research Center California University Berkeley, CA		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b>		<input type="radio"/> Production and Deployment
<b>Commercial</b> (415) 642-6000		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** ANALYSIS/Maintainability

**Date:** August 1979

**Title:** · Engineering Design Handbook; Maintainability  
Engineering Theory and Practice

**Synopsis:**

This report details maintainability design requirements and develops methodologies to be implemented to meet these requirements.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. C. Hunter  <b>Address:</b> DARCOM Alexandria, VA  <b>Telephone:</b> <b>Autovon</b> 284-8920 <b>Commercial</b> (301) 274-8920		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

7.9 CONTRACT  
APPLICATIONS

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## 7.1 RELIABILITY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Burn-In

**Synopsis:**

Due to the failure characteristics of electronic components, infant mortality failure rates are extremely high. To minimize this, it is standard practice to have electronic parts, capacitors, resistors, transistors, etc., burned in. The burn-in process is performed on electronic components before their release for normal use. This process allows infant mortality failures to occur in the factory rather than in the field, thus improving field reliability.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronics	Transistors, resistors, chips, etc.	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Ms. Grace A. Marseglia		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
<b>Address:</b> CORADCOM, DRDCO-PT-P Ft. Monmouth, NJ 07703		
<b>Telephone:</b>		
<b>Autovon</b> 995-2205 <b>Commercial</b> (201) 544-2205		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Early Build of Critical Subassembly Prototypes  
for Reliability Growth

**Synopsis:**

In many instances early in the design of equipment, certain sub-assemblies will be identified as harboring potential reliability problems or environmental design problems. It will be these subassemblies that will be the most troublesome during system testing, delaying test completion, requiring both contractor and Government attention, and diverting contractor resources possibly at a critical time in the program. Deferred fixes requiring expensive retrofit or "quick fixes" due to schedule restraints are sometimes the result.

It behooves the project manager to attack these reliability weak links as early as possible in the equipment life cycle. This can be accomplished usually following the testing and verification of design concept in the advanced development status (normally indications of potential reliability problems will surface during this phase). Consideration should be given at this time to the early build of critical subassembly prototypes for the

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronics	AN/TPQ-37 Firefinder	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. H. Selby  <b>Address:</b> ERADCOM-PM Firefinder Ft. Monmouth, NJ 07703  <b>Telephone:</b> <b>Autovon</b> 966-5152 <b>Commercial</b> (201) 544-5152		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

Title: Early Build of Critical Subassembly Prototypes for Reliability Growth

Synopsis: (Continued)

purpose of reliability growth and environmental testing. Reliability growth and the design change process (find, fix, and verify) are, by their nature, slow processes which require a dedicated effort. It is, therefore, crucial that hard work be dedicated to reliability growth and the finding of design deficiencies as early as possible.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Software Quality Assurance Program  
Requirements (MIL-S-52779)

**Synopsis:**

MIL-S-52779 requires the establishment and implementation of a Software Quality Assurance (QA) Program. The Software QA Program provides for detection, reporting, analysis, and correction of software deficiencies. The contractor is required to identify procedures used in issuing work tasking instructions for all work relating to software development, configuration management QA measures, testing of software, and corrective action procedures. In addition, the contractor is required to establish library controls and software documentation and outline review and audit procedures.

Use of the MIL-SPEC on weapon system programs requiring software development and implementation will improve the quality control of software.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. Hess, Mr. G. Newport		<input type="radio"/> Conception
<b>Address:</b> HQ-DARCOM, DRCQA-E 5001 Eisenhower Avenue Alexandria, VA 22333		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 284-8916		<input type="radio"/> Production and Deployment
<b>Commercial</b> (202) 274-8916		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Reliability Program for Systems and Equipment Development

**Synopsis:**

MIL-STD-785A, Reliability Program for Systems and Equipment Development and Production, is an exhibit which clarifies and defines the reliability program requirements. The purpose of this document is to specifically tailor an engineering development phase reliability program to comply with the provisions of Army Regulations 702-3, Army Materiel Reliability, Availability and Maintainability (RAM), and to best satisfy the special requirements inherent in tank-automotive weapon and support systems.

The document has not yet been applied to the procurement of a specific system and is intended to be used as an extension of a contract or RFP statement of work and is identified as a contract or RFP exhibit. It is not available through routine channels. COPIES OF THIS EXHIBIT SHOULD NOT BE REQUESTED THROUGH STANDARDIZATION DOCUMENT CHANNELS. Contact the point of contact for more information.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Vehicles	Various Tank-Automotive Systems	<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. P. Myron  <b>Address:</b> TACOM-DRDTA-PA Warren, MS 48090  <b>Telephone:</b> <b>Autovon</b> 273-2865 <b>Commercial</b> (313) 573-2865		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Employment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Reliability Program for Systems and Equipment Development

**Synopsis:**

This document (QR-800-J) is intended to be used as an extension of a contract or RFP statement of work and is identified as a contract or RFP exhibit.

This exhibit establishes criteria for a reliability program and provides guidelines for the preparation and implementation of a reliability program plan.

This exhibit is applicable to U.S. Army Missile R&D Command procurements for development and fabrication of materiel as specified in the RFP or the contract work order.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Missile	Various Missile Programs	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. W. L. Walker		<input type="radio"/> Conception
<b>Address:</b> MICOM-DRDMI-ORW Redstone Arsenal, AL 35809		<input type="radio"/> Validation
<b>Telephone:</b> 746-7570		<input checked="" type="radio"/> Full Scale Development
<b>Autovon</b> (205) 876-7570		<input type="radio"/> Production and Deployment
<b>Commercial</b>		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Guide to the Preparation of Data Items Requirements  
for R&M Programs

**Synopsis:**

MIRADCOM Document QR-816-D, dated 30 September 1977, Guide to the Preparation of Data Item Requirements for Reliability and Maintainability Programs, provides guidance to the RAM engineer preparing contract requirements for RAM programs in accordance with QR-800-G, QR-801-B, or QU-870-C.

This document is meant to assist the engineer when preparing an RFP or contract in accordance with MIL-STD-470 and 785 by listing appropriate data items which would improve a program audits management.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
Missile		<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. C. Cox		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment
Address: MICOM-DRMI-QRW Redstone Arsenal, AL 35809		
Telephone:		
Autovon 746-7342 Commercial (205) 876-7342		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Electronic Parts Reliability Control

**Synopsis:**

In order to upgrade reliability performance of electronic components in mission-essential missile, laser, and support system equipment, MIRADCOM has developed a parts screening policy which involves the review of contractors' parts data (including nonstandard parts specifications and drawings) for compliance to Army parts reliability requirements. The contractor is required to furnish the parts information in late advanced development and/or early engineering development. The policy was implemented through a change in MIRADCOM Specification MIL-E-11991, which now requires the use of Class A or Class B microcircuits, JANTX semiconductors, and Level P or better capacitors and resistors.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Missile Laser	Electronic Components	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. Heathcock  <b>Address:</b> MICOM Redstone Arsenal, AL 35809  <b>Telephone:</b> <b>Autovon</b> 746-4438 <b>Commercial</b> (205) 876-4438		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** August 1979

**Title:** Failure Review Boards

**Synopsis:**

An efficient management process for maintaining a smooth-running, up-to-date reliability program can be achieved through Failure Review Boards (FRBs). The initiation of a Failure Review Board is a method to focus attention on the importance of RAM characteristics throughout the development of an item. FRBs are normally headed by the contractor reliability engineer responsible for attaining the RAM goals. Board members usually include a Government representative, the contractor program manager, those personnel responsible for developing the major subsystems, and those involved in the failure analysis process.

The FRB, convening weekly, reviews recent system failures, delegates responsibility, initiates additional testing when required, directs resources to major problems, addresses consequences of proposed

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Electronics	AN/TPQ-36, AN/TPQ-37	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. H. Selby		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment
<b>Address:</b> ERADCOM PM-Firefinder Ft. Monmouth, NJ 07703		
<b>Telephone:</b>		
<b>Autovon</b> 966-5152 <b>Commercial</b> (201) 544-5152		

Title: Failure Review Boards

Synopsis: (Continued)

corrective actions with regard to the entire system, maintains a realistic and orderly schedule for attainment of RAM goals, and focuses attention on the overall system reliability, thereby optimizing reliability with respect to budget constraints.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability

**Date:** December 1979

**Title:** Reliability Management Review

**Synopsis:**

A procedure has been developed to effectively manage and enhance the reliability of developmental systems. The procedure should be contractually instituted to provide high visibility/priority. The system entails a series of contractor reviews/briefings which focuses attention and enhances effective corrective action taken on reliability-critical areas. The system may be applied throughout the life cycle; however, it is most beneficial in the developmental phase.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
	IFV/CFV	<input checked="" type="radio"/> Reliability <input checked="" type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> David M. Lewandowski  <b>Address:</b> Program Manager, Fighting Vehicle Systems ATTN: DRCPM-FVS-PA (D. Lewandowski) <b>Telephone:</b> Warren, MI 48090 Autovon 273-1038/2633 Commercial (313) 573-1038/2633		<input type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment

72 MANITABASHILTY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Maintainability

**Date:** August 1979

**Title:** Maintainability By Design

**Synopsis:**

The maintainability success of the T700 engine was a result of considering maintainability as a key design parameter. Unlike predecessor engine models, the design of the T700 engine emphasized stringent but practical maintainability requirements and their achievement during the development phase. Motivational management methods were employed in achieving the T700 maintainability goals of reduced maintainability and logistic requirements and low life-cycle cost. Examples of the methodology include the establishment of requirements and specifications such as the introduction of no new tools, the use of a minimum number of existing tools, elimination of special tools or adjustments, and accessibility to parts without removing other parts.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Engines	T700	<input type="radio"/> Reliability <input type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. Neff  <b>Address:</b> AVRADCOM-DRADAV-QR St. Louis, MO 63166  <b>Telephone:</b> <b>Autovon</b> 693-1575 <b>Commercial</b> (314) 263-1575		<input checked="" type="radio"/> Conception <input checked="" type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Maintainability

**Date:** August 1979

**Title:** Maintainability Program for Systems and Equipment Development

**Synopsis:**

Document QR-870-D is intended to be used as an extension of a contract or request for proposal (RFP) statement of work and is identified as a contract or RFP exhibit. It provides requirements for conducting a maintainability program during engineering development.

This exhibit is applicable to U.S. Army Missile R&D Command procurements for development and fabrication of material as specified in the RFP or the contract work statement.

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Missile	Various Missile Programs	<input type="radio"/> Reliability <input type="radio"/> Availability <input checked="" type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. W. L. Walker  <b>Address:</b> MICOM-DRDMI-QRW Redstone Arsenal, AL 35809  <b>Telephone:</b> <b>Autovon</b> 746-7570 <b>Commercial</b> (205) 876-7570		<input type="radio"/> Conception <input type="radio"/> Validation <input checked="" type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

7.3 RELIABILITY IMPROVE-  
MENT WARRANTY



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability  
Improvement Warranty

**Date:** August 1979

**Title:** Reliability Improvement Warranty Support for the Lightweight  
Doppler Navigation System

**Synopsis:**

The Lightweight Doppler Navigation System (LDNS) Program is under the management of the U.S. Army Navigation/Control (NAVCON) Systems Project Office at Fort Monmouth, New Jersey. In December 1976, Singer Company-Kearfott Division was awarded the initial production contract that included the reliability improvement warranty (RIW) terms and provisions. Prior to this contract effort, ARINC Research Corporation assisted the NAVCON Project Office during the engineering development (ED) phase of the LDNS Program and participated in the development of RIW terms and conditions of the initial production (IP) solicitation. ARINC Research provided engineering assistance in defining the Defense Contract Administration Services Office (DCASO) and the manufacturer's warranty responsibility by reviewing the contractor warranty data collection plan and developing LDNS field implementation plans.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. A. Bilodeau		<input type="radio"/> Conception
<b>Address:</b> ARINC Research Corp. 2551 Riva Rd. Annapolis, MD 21401		<input type="radio"/> Validation
<b>Telephone:</b> Autovon Commercial (301) 266-4000		<input type="radio"/> Full Scale Development
		<input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement  
Warranty

**Date:** August 1979

**Title:** Reliability Improvement Warranty Aspects of the AN/ARN-118 TACAN Program

**Synopsis:**

The reliability improvement warranty (RIW) is a procurement methodology, currently being tested by the Department of Defense, which attempts to align the contractor's profit incentive with increased equipment reliability. The basis for this study is the RIW contract which the Air Force developed and implemented on the AN/ARN-118 Airborne TACAN Program. The study primarily focuses on the pricing risk reduction efforts during the RIW contract development. The study concludes that the risk factors can be quantified and controlled, that contractor and Air Force incentives can be aligned to increase equipment reliability, and that RIW is a viable support concept.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
TACAN	AN/ARN-118	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. Hubbard		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
<b>Address:</b> Air Command and Staff College Maxwell AFB, Alabama		
<b>Telephone:</b>		
<b>Autovon</b> 875-1110 <b>Commercial</b> (205) 293-1110		



**Date:** August 1979

**Title:** Reliability Improvement Warranty (RIW) Experience

### Synopsis:

RIW is being utilized by the Army on the AN/ARN-123, AN/APN-209, T700 engine, and various Blackhawk components to improve their field reliability and reduce their support costs. RIW allows the Army to obtain a high performance guarantee on the equipment at a fixed cost from the contractor. The advantage of RIW contracts is the incentive it offers to contractors to improve equipment reliability and maintenance service with overall lower costs and higher profits. However, if reliability goals are not met, the contractor's costs increase in the form of hardware repair and, possibly, additional spares.

PREVIOUS APPLICATION					
Systems		Equipment Type		Applicability	
Helicopters Electronics		Blackhawk components, T700, ARN-123, APN-209		<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability	
Point of Contact				Life Cycle Phase	
<b>Name:</b> Mr. J. Lombardi      Mr. K. Zastrow  <b>Address:</b> AVRADCOM-DRADAV-QR      ERADCOM-DRDGL-PA St. Louis, MO 63166      Adelphi, MD 20783  <b>Telephone:</b> <b>Autovon</b> 693-1575                  290-3330 <b>Commercial</b> (314) 263-1575      (202) 394-3330				<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment	



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement Warranty

**Date:** August 1979

**Title:** Air Force RIW - Avionics

**Synopsis:**

A reliability improvement warranty (RIW) has been applied to nine items of avionics equipment in the F-16. These systems are:

Radar Antenna  
Radar Low Power RF  
Radar Digital Signal Processor  
Radar Computer  
Heads-Up Display  
Inertial Navigation System  
Flight Control Computer  
Radar Transmitter  
Heads-Up Display Electronics

(Continued)

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
Avionics	F-16	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:		<input type="radio"/> Conception
Address: F-16 System Program Office Aeronautical Systems Division Wright Patterson AFB, Dayton, OH		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon 787-1279		<input checked="" type="radio"/> Production and Deployment
Commercial (513) 257-1279		

Title: Air Force RIW - Avionics

Synopsis: (Continued)

Basically, under the RIW contract, warranted units which fail during the four-year warranty period will be returned to the manufacturer and will be repaired at his plant at no additional cost to the government.

In its most simple application, RIW clearly represents a definite departure from "business as usual." In the case of the F-16, there are many challenges associated with the management of the RIW program that have been encountered in the past. For example, the program includes:

RIW with a mean time between failure guarantee (MTBFG)

RIW at the line replacement unit (LRU) level

RIW at the module level

The RIW contract is between the government and the F-16 prime contractor. A number of RIW responsibilities have been delegated to four subcontractors by the prime contractor.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability  
Improvement Warranty

**Date:** August 1979

**Title:** RIW -- ARMY

**Synopsis:**

A long-term warranty, commonly known as the reliability improvement warranty (RIW), commits the contractor to perform depot-type repair services at a fixed price for a specified interval of operating time, calendar time, or both. The concept is typically implemented as a fixed-price contract provision to motivate the production contractor to design and produce equipment that will have a low rate of field failure as well as low repair costs in operational use. The fixed-price aspect of this procurement technique can also provide the incentive for a contractor to improve the reliability and maintainability of his equipment.

In January 1976, the Chief, Procurement Division, U. S. Army Materiel Development and Readiness Command (DARCOM) issued a policy letter to encourage

(Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Avionics	AN/ARN-123 R-1963 AN/APN-209 AN/ASN-128	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. J. Hess, Mr. G. Newport		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address: DARCOM/DRCQA-E Alexandria, VA		
Telephone:		
Autovon 284-8920 Commercial (301) 274-8920		

Title: RIW - ARMY

Synopsis: (Continued)

the use of RIW in Army contracts and to provide guidelines for such use.

During the past few years, RIW has been applied by the Army to the AN/ARN-123 Radio Receiving Set and R-1963 Glideslope Marker Beacon Receiver, manufactured by Bendix Corporation; the AN/APN-209 Altimeter, produced by Honeywell; and the AN/ASN-128 Lightweight Doppler Navigation System, manufactured by Singer-Kearfott. Several other avionic equipments are under consideration.

Limited experience in the application of RIW as a procurement technique by the Army has shown that if the RIW terms and conditions are properly structured and definitive plans are developed for implementing RIW, this procurement technique shows promise for application to Army avionics.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability  
Improvement Warranty

**Date:** August 1979

**Title:** The Application of Availability to Linear Indifference Contracting

**Synopsis:**

Necessary methods have been developed for applying both maintainability and reliability considerations to an incentive contracting plan that utilizes the concept of indifference. The resulting contracting scheme is applicable to situations where systems costs exhibit a linear relationship to system availability. The plan is such that the contractor is paid according to the availability demonstrated by the equipment during actual field use. Statistical techniques based on both consumers's risk and producer's risk are used in determining the required number of renewals. A procedure for establishing confidence limits on the purchase price is also derived. Both the cases for known standard deviation and unknown standard deviation are treated.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. T. Cronogue  <b>Address:</b> DARCOM Intern Training Cntr. Texarkana, Texas  <b>Telephone:</b> <b>Autovon</b> 829-5351 <b>Commercial</b> (214) 838-5351		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability  
Improvement Warranty

**Date:** August 1979

**Title:** Improvement of Weapon Systems' Reliability Through Reliability  
Improvement Warranties; AD-A042932

**Synopsis:**

This report outlines the basic causes of poor weapon systems reliability. These include (1) military requirements that demand greater improvements in capability over improvements in reliability, (2) inadequate development testing, and (3) the lack of incentive for producers of military hardware to increase reliability. The author explores the use of warranties by commercial airlines and its introduction into the Department of Defense. Two USAF applications of reliability improvement warranties (RIW), the F-111 Displacement Gyro and the ARN-118 TACAN, were analyzed using data through the end of CY 1976 in order to extract initial lessons learned. Continued emphasis on testing improvements, higher initial utilization of newly warranted equipments, education and evaluation of maintenance and supply personnel in RIW procedures, higher priorities for movement of failed units to contractor facilities, evaluation of a Swedish

(Continued)

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. J. Shmoldas		<input type="radio"/> Conception
<b>Address:</b> Defense Systems Management College Ft. Belvoir, VA		<input type="radio"/> Validation
<b>Telephone:</b>		<input type="radio"/> Full Scale Development
<b>Autovon</b> 354-6071		<input type="radio"/> Production and Deployment
<b>Commercial</b> (703) 664-6071		

Title: Improvement of Weapon Systems' Reliability Through Reliability  
Improvement Warranties

Synopsis: (Continued)

approach which utilizes military depots and existing logistics pipelines for servicing RIWs, and continued allocation of resources to improve reliability state of the art were recommended.



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement Warranty

**Date:** August 1979

**Title:** Reliability Improvement Warranties: An Analysis of Contractor Incentives and Risks

**Synopsis:**

The objective of this study was to analyze defense contractor perceptions of reliability improvement warranty incentives and risks. A thirty-question survey was sent to six companies with reliability improvement warranty experience. Survey results were integrated with follow-up telephone interviews and analysis of other warranty studies to complete the study. The study concludes that contractors see little incentive to improve equipment reliability any later than two years into a five-year warranty. One of several study recommendations is a proposal to implement reliability improvement warranties early in development programs to influence equipment design and lower contractor risks.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. R. Hudkins		<input type="radio"/> Conception
<b>Address:</b> Air Command and Staff College		<input type="radio"/> Validation
	Maxwell AFB, AL	<input type="radio"/> Full Scale Development
<b>Telephone:</b>		<input type="radio"/> Production and Deployment
<b>Autovon</b> 875-1110		
<b>Commercial</b> (205) 293-1110		



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement Warranty

**Date:** August 1979

**Title:** Reliability Improvement Warranties for Military Procurement

## Synopsis:

Consumer and commercial warranty experience alone does not justify optimistic expectations for RIWs. The effect of RIWs in completed DoD programs is inconclusive, and as a result of inadequate research design, the expectation of drawing meaningful conclusions from the ongoing RIW experiment may be over-optimistic. Examination of completed RIW programs, however, suggests the importance of (1) modification after operational use or testing, (2) schedule flexibility, (3) contractor involvement in initial overhaul and repair, and (4) avoidance of RIWs in programs subject to extreme quantity or utilization uncertainty. The design of the DoD's ongoing RIW experiment can be improved by (1) reducing the variation in contractual terms, (2) developing better controlled conditions, and (3) establishing defined limits for the experiment. In addition, the DoD must recognize the multiple objectives of the RIW and establish priority among them to facilitate evaluation.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b> Mr. A. Gandara  <b>Address:</b> Rand Corporation Santa Monica, CA  <b>Telephone:</b> Autovon Commercial (213) 393-0411		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement Warranty

**Date:** October 1980

**Title:** The Application of Reliability Improvement Warranty to Dynamic Systems; MERADCOM TQ-1; ARINC Research Publication 1736-01-1-2025

**Synopsis:**

The reliability improvement warranty (RIW) is currently used within the Department of Defense to provide an incentive to contractors to design and produce equipment that will have a low failure rate, as well as low costs of repair following failure in field or operational use. Current applications of RIW have generally been restricted to initial production procurements of relatively small, transportable avionics equipment.

The RIW concept has potential applications for dynamic systems (e.g., transmissions, gearboxes, engines, etc.) procured by the U.S. Army Mobility Equipment Research and Development Command (MERADCOM). However, dynamic systems may differ from avionics in design and maintenance concepts, transportability features, and deployment and utilization philosophy. Therefore, current criteria for using RIW and current guidelines for developing RIW terms and conditions should be reviewed and (Continued)

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
Mechanical	60 Kw Generator Set 25 Ton Container Handler	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:	Glenn Stewart	<input type="radio"/> Conception
Address:	U.S. Army Mobility Equipment Research and Development Command	<input type="radio"/> Validation
Telephone:	Product Assurance and Testing Directorate, DRDME-TQ	<input checked="" type="radio"/> Full Scale Development
Autovon	354-2037	<input checked="" type="radio"/> Production and Deployment
Commercial	(703) 664-2037	

Title: The Application of Reliability Improvement Warranty to  
Dynamic Systems

Synopsis: (Continued)

adapted for this new class of systems.

This effort identified several differences between the characteristics of dynamic systems and those of RIW avionics equipment that are not emphasized in current RIW guidelines. RIW application criteria for dynamic systems were also developed. An existing life-cycle cost (LCC) model was modified to address quantitative features of dynamic systems that should be considered in an economic analysis of RIW versus organic maintenance. Case studies were developed to demonstrate the use of the RIW selection criteria and the LCC model.

Point of contact at ARINC Research is:

Dr. R. A. Kowalski  
ARINC Research Corporation  
2551 Riva Road  
Annapolis, Maryland 21401

301-266-4000



# RAM DESIGN PRACTICES GUIDE

**Key Words:** CONTRACT APPLICATIONS/Reliability Improvement Warranty

**Date:** October 1980

**Title:** Warranted Component Management

**Synopsis:**

The many components of the Black Hawk aircraft which were covered by warranties could not be adequately managed by the available data feedback system (TAMMS, DA 2410). The Black Hawk program required much greater accuracy and timeliness. To accomplish the warranty administration, the Component Record for Intensive Management (CRIM) was developed and implemented. The data tracking system allows for accurate and timely reporting of all transactions on a warranted component and assures expeditious handling of all warranty claims.

PREVIOUS APPLICATION		
System	Equipment Type	Applicability
Helicopter	Black Hawk T-100 Engine	<input checked="" type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name: Mr. Edwin Hawkins		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input checked="" type="radio"/> Production and Deployment
Address: TSARCOM-DRSTS-QSM(2) St. Louis, MO 63120		
Telephone:		
Autovan 693-0290 Commercial (314) 263-0290		

APPENDIX I

## APPENDIX I

### STANDARDS, DIRECTIVES, AND OTHER DOCUMENTS PERTAINING TO RELIABILITY, AVAILABILITY, AND MAINTAINABILITY

#### Military Standards

MIL-STD-105D	Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-202E	Test Methods for Electronic and Electrical Component Parts
MIL-STD-414	Sampling Procedures and Tables for Inspection by Variables for Percent Defective
MIL-STD-415D	Test Provisions for Electronic Systems and Associated Equipment, Design Criteria for
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-471A	Maintainability Demonstration
MIL-STD-481A	Configuration Control -- Engineering Changes, Deviations, and Waivers (Short Form)
MIL-STD-482A	Configuration Status Accounting -- Data Elements and Related Features
MIL-STD-490	Specification Practices
MIL-STD-499A	Engineering Management
MIL-STD-721B	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors, and Safety
MIL-STD-756A	Reliability Prediction
MIL-STD-757	Reliability Evaluation from Demonstration Data
MIL-STD-781C	Reliability Tests: Exponential Distribution
MIL-STD-785B	Reliability Program for Systems and Equipment Development and Production
MIL-STD-790C	Reliability Assurance Program for Electronic Parts Specifications
MIL-STD-881A	Work Breakdown Structures for Defense Material Items
MIL-STD-965	Parts Control Program

APPENDIX I (Continued)

MIL-STD-1304A	Reliability Report
MIL-STD-1472B	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities
MIL-STD-882A	System Safety Program Requirements
MIL-STD-1629(SHIPS)	Procedures for Performing A Failure Modes and Effects Analysis for Shipboard Equipment
MIL-STD-2068(AS)	Reliability Development Tests
MIL-STD-2070(AS)	Procedures for Performing A Failure Modes, Effects, and Criticality Analysis for Aeronautical Equipment
MIL-STD-2072(AS)	Survivability, Aircraft; Establishment and Conduct of Programs

## APPENDIX I (Continued)

### Military Specifications

MIL-H-46855B	Human Engineering Requirements for Military Systems, Equipment, and Facilities
MIL-Q-9858A	Quality Program Requirements
MIL-M-24365A	Maintenance Engineering Analysis, Establishment of, and Procedures and Formats for Associated Documentation, General Specification for

### Military Handbooks

MIL-HDBK-53	Guide for Sampling Inspection
MIL-HDBK-106	Multi-Level Sampling Procedures and Table for Inspection by Attributes
MIL-HDBK-107	Inspection and Quality Control -- Single Level Continuous Sampling Procedures and Tables for Inspection by Attributes
MIL-HDBK-108	Quality Control and Reliability -- Sampling Procedures and Tables for Life and Reliability Testing (Based on Exponential Distribution)
MIL-HDBK-109	Quality Control and Reliability -- Statistical Procedures for Determining Validity of Suppliers Attributes, Inspection of
MIL-HDBK-175	Microelectronic Device Data Handbook
MIL-HDBK-217C	Reliability Prediction of Electronic Equipment
MIL-HDBK-472	Maintainability Prediction
MIL-HDBK-251	Reliability/Design Thermal Applications

## APPENDIX I (Continued)

### U.S. Navy Documentation

SECNAVINST 3900.36A	Reliability and Maintainability (RM) of Naval Material, Policy for
SECNAVINST 4000.29A	Development of Integrated Logistic Support for Systems/ Equipments
NAVMATINST 4000.20A	Integrated Logistic Support Planning Procedures

### U.S. Army/Air Force Documentation

AFSC DH 1-3	Personnel Subsystems
AFSC DH 1-9	Maintainability
AMCP 11-3	Value Engineering Program Management Guidelines
AMCP 715-3	Proposal Evaluation and Source Selection
DA PAM 11-25	Life Cycle System Management Model for Army Systems

### Miscellaneous

AD-A009-045	Maintainability Engineering Design Notebook
AD-A024-601	Reliability Design Handbook
RADC-TR-75-22	Non-Electronic Reliability Notebook
LD 35204A	RAM Handbook for the Combat Developer
LD 32447A	Reliability and Maintainability Planning Guide for Army Aviation Systems and Components
*	RAM Requirements in the Procurement of Munition Production Systems
RADC-TR-77-287 (AD-A050837)	A Redundancy Notebook
RADC-TR-78-224 (AD-A069384)	A Guide to Built-in Test

\* Available from USAMMRC

**APPENDIX II**

## APPENDIX II

### U.S. ARMY ENGINEERING DESIGN HANDBOOKS

<u>No.</u>	<u>Title</u>
AMCP 706-	
100	Design Guidance for Producibility
104	Value Engineering
106	Elements of Armament Engineering, Part One, Source of Energy
107	Elements of Armament Engineering, Part Two, Ballistics
108	Elements of Armament Engineering, Part Three, Weapon Systems and Components
109	Tables of the Cumulative Binomial Probabilities
110	Experimental Statistics, Section 1, Basic Concepts and Analysis of Measurement Data
111	Experimental Statistics, Section 2, Analysis of Enumerative and Classifactory Data
112	Experimental Statistics, Section 3, Planning and Analysis of Comparative Experiments
113	Experimental Statistics, Section 4, Special Topics
114	Experimental Statistics, Section 5, Tables
115	Environmental Series, Part One, Basic Environmental Concepts
116	Environmental Series, Part Two, Natural Environmental Factors
117	Environmental Series, Part Three, Induced Environmental Factors
118	Environmental Series, Part Four, Life Cycle Environments
119	Environmental Series, Part Five, Glossary of Environmental Terms
120	Criteria for Environmental Control of Mobile Systems
121	Packaging and Pack Engineering
123	Hydraulic Fluids
124	Reliable Military Electronics
125	Electrical Wire and Cable
127	Infrared Military Systems, Part One
128 (S)	Infrared Military Systems, Part Two (U)
130	Design for Air Transport and Airdrop of Material
132	Maintenance Engineering Techniques (MET)
133	Maintainability Engineering Theory and Practice (METAP)
134	Maintainability Guide for Design
135	Inventions, Patents, and Related Matters
136	Servomechanisms, Section 1, Theory
137	Servomechanisms, Section 2, Measurement and Signal Converters
138	Servomechanisms, Section 3, Amplifier
139	Servomechanisms, Section 4, Power Elements and System Design
140	Trajectories, Differential Effects, and Data for Projectiles
150	Interior Ballistics of Guns
158	Fundamentals of Ballistic Impact Dynamics, Part One
159 (S)	Fundamentals of Ballistic Impact Dynamics, Part Two (U)
160 (C)	Elements of Terminal Ballistics, Part One, Kill Mechanisms and Vulnerability (U)

# APPENDIX II (Continued)

<u>No.</u>	<u>Title</u>
AMCP 706-	
161(C)	Elements of Terminal Ballistics, Part Two, Collection and Analysis of Data Concerning Targets
162(SRD)	Elements of Terminal Ballistics, Part Three, Application to Missile and Space Targets (U)
163(S)	Basic Target Vulnerability (U)
165	Liquid-Filled Projective Design
170(S)	Armor and Its Applications (U)
175	Solid Propellants, Part One
176	Solid Propellants, Part Two
177	Properties of Explosives of Military Interest
178	Properties of Explosives of Military Interest, Section 2 (Replaced by -177)
179	Explosive Trains
180	Principles of Explosive Behavior
181	Explosions in Air, Part One
182(SRD)	Explosions in Air, Part Two (U)
185	Military Pyrotechnics, Part One, Theory and Application
186	Military Pyrotechnics, Part Two, Safety, Procedures and Glossary
187	Military Pyrotechnics, Part Three, Properties of Materials Used in Pyrotechnics Compositions
188	Military Pyrotechnics, Part Four, Design of Ammunition for Pyrotechnics Effects
189	Military Pyrotechnics, Part Five, Bibliography
190	Army Weapon System Analysis
191	System Analysis and Cost-Effectiveness
192	Computer Aided Design of Mechanical Systems, Part One
193	Computer Aided Design of Mechanical Systems, Part Two
195	Development Guide for Reliability, Part One, Introduction, Background and Planning for Army Materiel Requirements
196	Development Guide for Reliability, Part Two, Design for Reliability
197	Development Guide for Reliability, Part Three, Reliability Prediction
198	Development Guide for Reliability, Part Four, Reliability Measurement
199	Development Guide for Reliability, Part Five, Contracting for Reliability
200	Development Guide for Reliability, Part Six, Mathematical Appendix and Glossary
201	Helicopter Engineering, Part One, Preliminary Design
202	Helicopter Engineering, Part Two, Detail Design
203	Helicopter Engineering, Part Three, Qualification Assurance
204	Helicopter Performance Testing
205	Timing Systems and Components
210	Fuzes
211(C)	Fuzes, Proximity, Electrical, Part One (U)
212(S)	Fuzes, Proximity, Electrical, Part Two (U)
213(S)	Fuzes, Proximity, Electrical, Part Three (U)
214(S)	Fuzes, Proximity, Electrical, Part Four (U)

APPENDIX II (Continued)

<u>No</u>	<u>Title</u>
AMCP 702-	
10	Guide to Nondestructive Testing Techniques
11	Guide to Specifying NDT in Material Life-Cycle Applications

**APPENDIX III**



# RAM DESIGN PRACTICES GUIDE

**Key Words:**

**Date:**

**Title:**

**Synopsis:**

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:		<input type="radio"/> Conception
Address:		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon		<input type="radio"/> Production and Deployment
Commercial		



# RAM DESIGN PRACTICES GUIDE

**Key Words:**

**Date:**

**Title:**

**Synopsis:**

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:		<input type="radio"/> Conception
Address:		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon		<input type="radio"/> Production and Deployment
Commercial		



# RAM DESIGN PRACTICES GUIDE

Key Words:

Date:

Title:

Synopsis:

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:		<input type="radio"/> Conception
Address:		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon		<input type="radio"/> Production and Deployment
Commercial		



# RAM DESIGN PRACTICES GUIDE

**Key Words:**

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**Title:**

**Synopsis:**

PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
Name:		<input type="radio"/> Conception
Address:		<input type="radio"/> Validation
Telephone:		<input type="radio"/> Full Scale Development
Autovon		<input type="radio"/> Production and Deployment
Commercial		



# RAM DESIGN PRACTICES GUIDE

**Key Words:**

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**Title:**

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PREVIOUS APPLICATION		
Systems	Equipment Type	Applicability
		<input type="radio"/> Reliability <input type="radio"/> Availability <input type="radio"/> Maintainability
Point of Contact		Life Cycle Phase
<b>Name:</b>  <b>Address:</b>  <b>Telephone:</b> Autovon Commercial		<input type="radio"/> Conception <input type="radio"/> Validation <input type="radio"/> Full Scale Development <input type="radio"/> Production and Deployment

APPENDIX IV